SAMPLING, REDUCTION & DENSITY

(ENGLISH VERSION)

Table of Contents

COURSE OBJECTIVES AND SCHEDULE

LEARNING OBJECTIVES:

Instructional objectives for this course include:

Develop a background in measurements and calculations
Understand random sampling
Understand the basics of construction and materials
Become knowledgeable in highway materials terminology
Become proficient in the following test procedures:

FOP for AASHTO T2
Standard Method of Test for Sampling Aggregates

FOP for AASHTO T248
Standard Method of Test for Reducing Aggregate Samples to Testing Size

FOP for AASHTO T168
Standard Method of Test for Sampling Bituminous Paving Mixtures

FOP for AASHTO T328
Standard Method of Test for Reducing HMA Samples to Testing Size

FOP for AASHTO T40
Standard Method of Test for Sampling Bituminous Liquids

FOP for AASHTO T 310
Standard Specification for In-Place Density and Moisture Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

FOP for Test Method TM-8
In-Place Density of Bituminous Mixes Using the Nuclear Moisture-Density Gauge

SCHEDULE:

Day 1

0900 Welcome, and Introduction

0915 Presentations on Course Materials, Including Background Information and FOP's

1200 End

Day 2

0900 Written Exam, Followed by Performance Exam

COURSE EVALUATION FORM

The UDOT Transportation Technician Qualification Program would appreciate your thoughtful completion of all items on this evaluation form. Your comments and constructive suggestions will be an asset in our continuing efforts to improve our course content and presentations.

Course Title: _____

Location: _____

Dates: _____

Your Name (Optional): _____

Employer: _____

Instructor(s) _____

COURSE CONTENT

Will the course help you perform your job better and with more understanding? Yes Maybe No

Explain: _____

_____

Was there an adequate balance between theory and instruction? Yes Maybe No

Explain: _____

_____

Did the course prepare you to confidently complete both examinations? Yes Maybe No

Explain: _____

_____

What was the most beneficial aspect of the course? _____

_____

What was the least beneficial aspect of the course? _____

_____

GENERAL COMMENTS

General comments on the course, content, materials, presentation method, facility, registration process, etc. Include suggestions for additional Tips!

INSTRUCTOR EVALUATION

Were the objectives of the course, and the instructional and exam approach, clearly explained? Yes Maybe No

Explain:

Was the information presented in a clear, understandable manner? Yes Maybe No

Explain:

Did the instructors demonstrate a good knowledge of the subject? Yes Maybe No

Explain:

Did the instructors create an atmosphere in which to ask questions and hold open discussion? Yes Maybe No

Explain:

BACKGROUND ON MEASUREMENTS AND CALCULATIONS

Introduction

This section provides a background in the mathematical rules and procedures used in making measurements and performing calculations. Topics include:

- Units: Metric and English
- Mass vs. Weight
- Balances and Scales
- Rounding
- Significant Figures
- Accuracy and Precision
- Tolerance

Also included is a discussion of real-world applications in which the mathematical rules and procedures may not be followed.

Units: Metric and English

Although English units are considered the standard, this document also frequently uses Metric units.

We use Metric units most often for determining mass and weight, or where its usage is more appropriate than English. For example, many AASHTO standards are written using exclusively Metric units with no English equivalents given.

It is often necessary to convert Metric to English units. Depending on the situation, some conversions are exact, and some are approximate. One inch is exactly 25.4 mm. One pound is approximately 454 grams. When making conversions, it is important to be accurate enough that the test results do not become biased. For instance, when performing a test where mass is measured in grams but the test result must be expressed in pounds, conversion from grams to pounds will be necessary. In this case, we might choose to divide the mass in grams by 453.6 to arrive at the number of pounds. This gives a more accurate conversion than using the approximate equivalent of 454 grams per pound.

Basic units in Metric include:

Length:	meter, m
Mass:	kilogram, kg
Time:	second, s

Derived units include:

Force:	Newton, N

Metric Units

Metric	English
25 mm	1 in.
1 kg	2.2 lb
454 g	1 lb
1000 kg/m^3	62.4 lb/ft^3
25 MPa	3600 lb/$in.^2$
1 liter	1 qt

Some Approximate Metric/English Equivalents

Mass vs. Weight

The terms mass, force, and weight are often confused. Mass is a measure of an object's material makeup, and has no direction. Force is a measure of a push or pull, and has the direction of the push or pull. Force (F), is equal to mass (m), times acceleration (a).

$$F = ma$$

Weight is a special kind of force, caused by gravitational acceleration. Weight (W), is equal to mass (m), times the acceleration due to gravity (g), and is directed toward the center of the earth.

$$W = mg$$

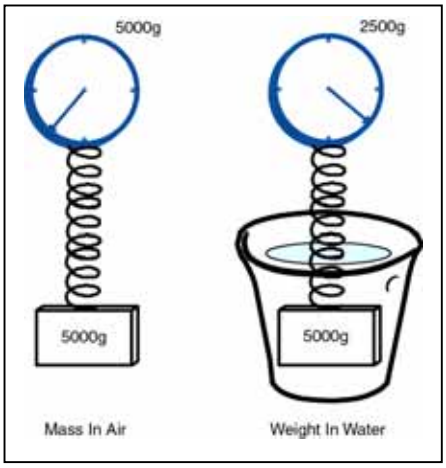
In the English system, mass can be measured in pounds-mass (lb_m), while acceleration is in feet per square second (ft/s^2), and force is in pounds-force (lb_f). An object having a mass of 185 lb_m has a weight of 185 lb_f when subjected to the earth's standard gravitational pull. If this object were on the moon, where the acceleration due to gravity is about one-sixth of what it is on earth, its weight would be about 31 lb_f, but its mass would still be 185 lb_m.

	Earth	Moon
Gravity	1 G	$^1/_6$ G
Mass	185 lb_m	185 lb_m
Weight	185 lb_f	31 lb_f

Comparison of Mass and Weight

While the acceleration due to gravity does vary with position on the earth (latitude and elevation), the variation is not significant except for extremely precise work – the manufacture of electronic memory chips, for example.

As discussed above, there are two kinds of pounds, lb_m and lb_f. In laboratory measurements, grams or kilograms (not pounds) are the units of choice. But, is this mass or force? Technically, it depends on the instrument used, but practically speaking, mass is the result of the measurement. When using a scale, force is being measured – either electronically by the stretching of strain gauges or mechanically by the stretching of a spring or other device. When using a balance, mass is being measured, because the mass of the object is being compared to a known mass built into or attached to the balance.



Submerged Weight

In this document, mass, not weight, is used in test procedures except when determining "weight" in water. When an object is submerged in water (as is done in specific gravity tests), the term weight is used. Technically, what is being measured is the force the object exerts on the balance or scale while the object is submerged in water (or the submerged weight). This force is actually the weight of the object less the weight of the volume of water displaced.

In summary, whenever the common terms "weight" and "weighing" are used, the more appropriate terms "mass" and "determining mass" are usually implied, except in the case of weighing an object submerged in water.

Balances and Scales

Balances, technically used for mass determinations, and scales, used to weigh items, were discussed briefly above in the section on "Mass vs. Weight." In field operating procedures, we usually do not differentiate between the two types of instruments. When using either one for a material or object in air, we are determining mass. For those procedures in which the material or object is suspended in water, we are determining weight in water.

AASHTO recognizes two general categories of instruments. Standard analytical balances are used in laboratories. For most field operations, general purpose balances and scales are specified. Specifications for both categories are shown in Tables 1 and 2.

Table 1
Standard Analytical Balances

Class	Capacity	Readability and Sensitivity	Accuracy
A	200 g	0.0001 g	0.0002 g
B	200 g	0.001 g	0.002 g
C	1200 g	0.01 g	0.02 g

Table 2
General Purpose Balances and Scales

Class	Principal Sample Mass	Readability and Sensitivity	Accuracy
G2	2 kg or less	0.1 g	0.1 g or 0.1 percent
G5	2 kg to 5 kg	1 g	1 g or 0.1 percent
G20	5 kg to 20 kg	5 g	5 g or 0.1 percent
G100	Over 20 kg	20 g	20 g or 0.1 percent

Rounding

Numbers are commonly rounded up or down after measurement or calculation. For example, 53.67 would be rounded to 53.7 and 53.43 would be rounded to 53.4, if rounding to the nearest 0.1 were required. The first number was rounded up because 53.67 is closer to 53.7 than to 53.6. Likewise, the second number was rounded down because 53.43 is closer to 53.4 than to 53.5. The reasons for rounding will become apparent in the next section on “Significant Figures.”

If the number being rounded ends with a 5, two possibilities exist (round up or down). In the more mathematically sound approach, numbers are rounded so that the number to the left of the 5 becomes even. Thus, 102.25 would be rounded down to 102.2, while 102.35 would be rounded up to 102.4. This procedure avoids the bias that would exist if all numbers ending in 5 were rounded up or all numbers were rounded down. In some calculators, however, all rounding is up. This does result in some bias, or skewing of data, but the significance of the bias is not usually important to the calculations used in material testing.

Significant Figures

- General

A general purpose balance or scale, classified as G20 in AASHTO M 231, has a capacity of 20,000 g and an accuracy requirement of ±5 g. A mass of 18,285 g determined with such an instrument could actually range from 18,280 g to 18,290 g. Only four places in the measurement are significant. The fifth (last) place is not significant since it may change.

Mathematical rules exist for handling significant figures in different situations.

For example, when performing addition and subtraction, the number of significant figures in the sum or difference is determined by the least precise input. Consider the three situations shown below:

Situation 1	Situation 2	Situation 3
35.67	143.903	162
+ 423.938	– 23.6	+33.546
		– 0.022
= 459.61	= 120.3	= 196
not 459.608	not 120.303	not 195.524

Rules also exist for multiplication and division. These rules, and the rules for mixed operations involving addition, subtraction, multiplication, and/or division, are beyond the scope of these materials. AASHTO covers this topic to a certain extent in the section called “Precision” or “Precision and Bias” included in many test methods, and the reader is directed to those sections if more detail is desired.

- Real World Limitations

While the mathematical rules of rounding have been established, they are not always followed. For example, AASHTO Method of Test T 176, *Plastic Fines in Graded Aggregates and Soils by the Use of the Sand Equivalent Test*, prescribes a method for rounding in conflict with the mathematical rules. In this procedure, calculated values are always

rounded up. Rounded numbers are used to calculate the Sand Equivalent, which is the ratio of the sand reading to the clay reading multiplied by 100. In this case:

$$\frac{3.3}{8.0} \times 100 = 41.250...,$$

rounded to 41.3 and reported as 42

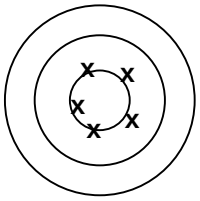
When multiple sand equivalent values are averaged, we round up again. For example:

42 + 43 + 42 = 42.3, reported as 43

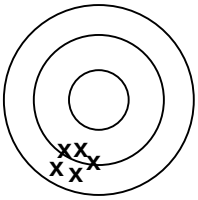
It is extremely important that engineers and technicians understand the rules of rounding and significant digits just as well as they know procedures called for in standard test methods.

Accuracy and Precision

Although often used interchangeably, the terms accuracy and precision do not mean the same thing. In an engineering sense, accuracy denotes nearness to the truth or some value accepted as the truth, while precision relates to the degree of refinement or repeatability of a measurement.



ACCURATE BUT NOT PRECISE, SCATTERED



PRECISE BUT NOT ACCURATE, BIASED

Two bullseye targets are shown to the left. The upper one indicates hits that are scattered, but whose average is very close to the center. The lower one has a tight pattern, but all the hits are biased from the center. The upper one is more accurate, while the lower one is more precise. A biased, but precise, instrument can often be adjusted physically or mathematically to provide reliable single measurements. A scattered, but accurate, instrument can be used if enough measurements are made to provide a valid average.

To further illustrate this same concept, consider the measurement of the temperature of boiling water at standard atmospheric pressure by two thermometers. Five readings were taken with each, and the values were averaged.

Thermometer No. 1	Thermometer No. 2
214.2°F	213.1°F
214.0°F	210.6°F
214.2°F	210.0°F
214.0°F	213.8°F
214.2°F	212.5°F
AVG = 214.1°F	AVG = 212.0°F

Thermometer No. 1 shows very little fluctuation, but is off the known boiling point (212.0°F) by 2.1°F. No. 2 has an average value equal to the known boiling point, but shows quite a bit of fluctuation. While we may not desire to use either thermometer, No. 1 could be employed if 2.1°F were subtracted from each measurement, and No. 2 could be used if enough measurements were made to provide a valid average.

Engineering and scientific instruments should be calibrated and compared against reference standards periodically to assure that measurements are accurate. If such checks are not performed, the accuracy is uncertain, no matter what the precision. Calibration of an instrument removes fixed error, leaving only random error for concern.

Tolerance

Dimensions of constructed or manufactured objects, including laboratory test equipment, cannot be specified exactly. Some tolerance must be allowed. Thus, procedures for including tolerance in addition/subtraction and multiplication/division operations must be understood.

- Addition and Subtraction

When adding or subtracting two numbers that individually have a tolerance, the tolerance of the sum or difference is equal to the sum of the individual tolerances.

For example, if two values are added, one being 113.361 ±0.006 and the other being 87.242 ±0.005 then the tolerance of the sum is:

(0.006) + (0.005) = 0.011

and the sum would be 200.603 ±0.011.

- Multiplication and Division

To demonstrate the determination of tolerance for the product of two numbers, consider determining the area of a rectangle having sides of 76.254 ±0.009 and 34.972 ±0.007. The percentage variations of the two dimensions are:

$$\frac{0.009}{76.254} \times 100 = 0.01\%$$

and

$$\frac{0.007}{34.972} \times 100 = 0.02\%$$

The sum of the percentage variations is 0.03 percent, the variation that is employed in the area of the rectangle. In this case, if the values are expressed in feet, then:

Area = 76.254 ft ∀ 0.01% x 34.972 ft ∀ 0.02%

Area = 2666.8 ft^2 ±0.03 percent

or

2666.8 ± 0.8ft^2.

- Real World Applications

Tolerances are used whenever a product is manufactured. For example, one of the molds used for determining soil density in AASHTO T 99 has a diameter of 4.000±0.016 in and a height of 4.584±0.005 in.

Using the smaller of each dimension results in a volume of:

$(\pi/4)\ (3.984\ in)^2\ (4.579\ in) =$

$57.082 in^3$ or $0.0330\ ft^3$

Using the larger of each dimension results in a volume of:

$(\pi/4)\ (4.016\ in)^2\ (4.589\ in) =$

$58.130\ in^3$ or $0.0336\ ft^3$

The average value is 0.0333, and AASHTO T 99 specifies a volume of:

$0.0333 \pm 0.0003\ ft^3$

or a range of

0.0330 to $0.0336\ ft^3$

Because of the variation that can occur, some agencies periodically calibrate molds, and make adjustments to calculated density based on those calculations.

Summary

Mathematics has certain rules and procedures for making measurements and performing calculations that are well established. Most of the time these agree with the standardized procedures we must follow to perform tests, but occasionally they do not. Engineers and technicians must be familiar with both, but must follow test procedures in order to obtain valid, comparable results.

RANDOM SAMPLING OF CONSTRUCTION MATERIALS

Significance

Sampling and testing are two of the most important functions in quality assurance and quality control (QA & QC). Data from the tests are the tools with which the quality of products is controlled, and on which acceptance is based. For this reason, great care must be used in following standardized sampling and testing procedures.

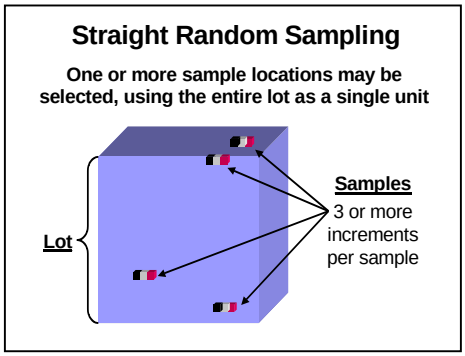
In controlling operations, it is necessary to obtain numerous samples at various points during production or installation of construction materials. Unless precautions are taken, sampling can occur in patterns that may impart a bias to the data gathered. Sampling at the same time, say noon, each day may jeopardize the effectiveness of any quality program. This might occur, for example, because a material producer does certain operations, such as cleaning screens at an aggregate plant, late in the morning each day. To obtain a representative sample, a reliable system of random sampling must be employed.

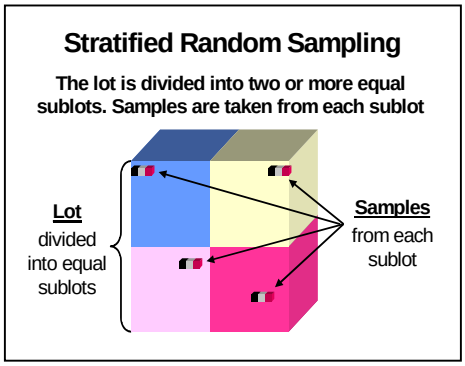
Scope

The procedure presented here eliminates bias in sampling materials. Randomly selecting a set of numbers from a table, calculator, or computer will eliminate the possibility for bias. Random numbers are used to identify sampling times, locations, or points within a lot or sublot. This method does not cover how to sample, but rather how to determine where or when to sample.

Sampling Concepts

A lot is the quantity of material evaluated by QA or QC procedures. A lot is a preselected quantity that may represent hours of production, a quantity or number of loads of material, or an interval of time. A lot may be comprised of several portions that are called sublots or units. The number of sublots comprising a lot will be determined by the agency's specifications.





Straight Random Sampling vs. Stratified Random Sampling: Straight random sampling considers an entire lot as a single unit and determines each sample location based on the entire lot size. Stratified random sampling divides the lot into a specified number of sublots or units and then determines each sample location within a distinct sublot. Both methods result in random distribution of samples to be tested for compliance with the agency's specification.

Agencies stipulate when to use straight random sampling or stratified random sampling. AASHTO T 2, Sampling of Aggregates, for example, specifies a straight random sampling procedure.

Picking Random Numbers from a Table

Table 1 contains pairs of numbers. The first number is the "pick" number and the second is the Random Number, "RN". The table was generated with a spreadsheet and the cells (boxes at the intersection of rows and columns) containing the RNs actually contain the "random number function". Every time the spreadsheet is opened or changed, all the RNs change.

- Select a Pick number in a random method. The first two or last two digits in the next automobile license plate you see would be one way to select. Another would be to start a digital stop watch and stop it several seconds later, using the decimal part of the seconds as your Pick number.
- Find the RN matching the Pick number.

TABLE 1
Random Numbers

Pick	RN	Pick	RN	Pick	RN	Pick	RN	Pick	RN
01	0.998	21	0.758	41	0.398	61	0.895	81	0.222
02	0.656	22	0.552	42	0.603	62	0.442	82	0.390
03	0.539	23	0.702	43	0.150	63	0.821	83	0.468
04	0.458	24	0.217	44	0.001	64	0.187	84	0.335
05	0.407	25	0.000	45	0.521	65	0.260	85	0.727
06	0.062	26	0.781	46	0.462	66	0.815	86	0.708
07	0.370	27	0.317	47	0.553	67	0.154	87	0.161
08	0.410	28	0.896	48	0.591	68	0.007	88	0.893
09	0.923	29	0.848	49	0.797	69	0.759	89	0.255
10	0.499	30	0.045	50	0.638	70	0.925	90	0.604
11	0.392	31	0.692	51	0.006	71	0.131	91	0.880
12	0.271	32	0.530	52	0.526	72	0.702	92	0.656
13	0.816	33	0.796	53	0.147	73	0.146	93	0.711
14	0.969	34	0.100	54	0.042	74	0.355	94	0.377
15	0.188	35	0.902	55	0.609	75	0.292	95	0.287
16	0.185	36	0.674	56	0.579	76	0.854	96	0.461
17	0.809	37	0.509	57	0.887	77	0.240	97	0.703
18	0.105	38	0.013	58	0.495	78	0.851	98	0.866
19	0.715	39	0.497	59	0.039	79	0.678	99	0.616
20	0.380	40	0.587	60	0.812	80	0.122	00	0.759

Picking Random Numbers with a Calculator or Computer

Many calculators and computer programs have a built-in random number function. To obtain a random number, key in the code or push the button(s) the calculator's instructions call for. The display will show a number between 0.000 and 1.000 and this will be your random number.

Documentation

Documentation of random number (RN) selection is as important as determining the RN's, since it is critical to proper record keeping to show how they were obtained. In addition to listing the RN's, the documentation should describe who obtained them, what assumptions or specifications governed their selection, and a specific reference as to the source.

Examples of Random Sampling Procedures Using Random Numbers

Agencies often specify the frequency of sampling in terms of mass of production, time, number of haul units, or amount of in-place material.

- **Sampling Based on Mass of Production:**

The specification might call for one sample from every 1000 Tons (T) of aggregate. If the random number was 0.317, the sample would be taken at (0.317)(1000 T) = 317 T.

- **Sampling Based on Time:**

One sample per day might also be specified. If the day were 9 hours long and the random number 0.199, the sample would be taken at (0.199)(9 hrs) = 1.79 hr = 1 hr, 47 minutes into the day. AASHTO T 2 permits this time to be rounded to the nearest 5 minutes.

- **Sampling from Haul Units:**

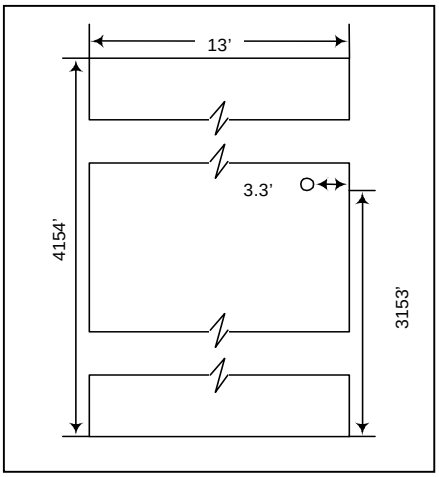
Based on the agency's specifications (in terms of time, volume, or mass) determine the number of haul units that comprise a lot. Multiply the selected random number(s) by the number of units to determine which unit(s) will be sampled.

For example, if 20 haul units comprise a lot and one sample is needed, pick one RN. If the RN were 0.773, then the sample would be taken from the (0.773)(20) = 15.46, or 16th haul unit.

- **Sampling from a Roadway with Previously Placed Material:**

The agency's specified frequency of sampling (in time, volume, or mass) can be translated into a location on a job. In this example one sample per lot is required. Given that the size of the lot is equal to 1000yd^3 and material is being placed 0.50' thick and 13' wide, then the lot is 4154' long.

$$\frac{1000\ yd^3 \times 27}{13' \times 0.5'} = 4154'$$



Sampling From a Roadway

In this case, you would select two RNs to determine the coordinates of the sample location. For example, a first RN of 0.759 would specify that the sample would be taken at (0.759)(4154') = 3153' from the beginning. A second RN of 0.255 would specify that the sample would be taken at (0.255)(13') = 3.3' from the right edge.

To avoid problems associated with taking samples too close to the edge, no sample is taken closer than 1' to the edge. If the RN specifies a location closer than 1', then 1' is added to or subtracted from the distance calculated.

- **Sampling from a Stockpile:**

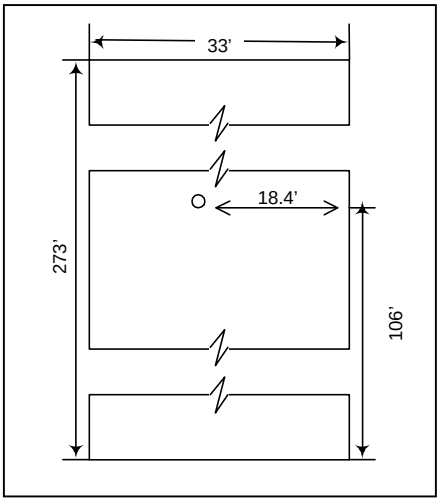
AASHTO T 2 recommends against sampling from stockpiles. However, some agencies use random procedures in determining sampling locations from a stockpile. Stockpiles are prone to segregation and a sample obtained from a stockpile may not be representative. Refer to AASHTO T 2 for guidance on how to sample from a stockpile.

- **In-Place Density Testing:**

In the following example a lot is one days production, divided into sublots of 1000 yd^2, requiring one test per sublot. If material is being placed 33' wide, then the sublot is 273' long.

$$\frac{1000\ yd^2\ x\ 9}{33'} = 273'$$

You would select two RNs to determine the coordinates of the test location within the sublot. A first RN of 0.387 would specify that the sample would be taken at (0.387)(273') = 106' from the beginning. A second RN of 0.558 would specify that the sample would be taken at (0.558)(33') = 18.4' from the right edge. If the RN specifies a location closer than 1' to the edge, then 1' is added to or subtracted from the distance calculated.



In-Place Density Testing

Summary

It is critical that technicians and engineers understand the significance of randomly determining sample and test locations or intervals. Use of random numbers, and application of the principles introduced in this section, gives every portion of the lot or sublot an equal chance of being sampled or tested without introduction of bias.

It is also important to accurately document the assumptions and/or specifications governing random number generation, and what method was used to obtain them.

BASICS OF AGGREGATE

Introduction

01 Properties of aggregate materials depend upon mineral constituents present in parent rock formations. Rock is grouped in three major classes:

- Igneous
- Sedimentary
- Metamorphic

02 Classes are divided into types, which are further divided into families.

Class	Type	Family
Igneous		
	Intrusive	
		Granite
	Extrusive	
		Basalt
Sedimentary		
	Calcareous	
		Limestone
	Siliceous	
		Sandstone
Metamorphic		
	Foliated	
		Slate
	Non-foliated	
		Marble

Rock class, type, family

Geology

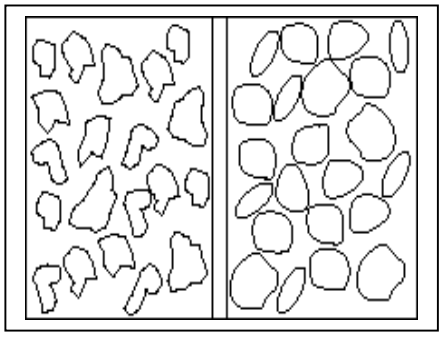
03 Igneous rocks are formed by solidification of molten rock. Grain size depends on the rate of cooling. Rapid cooling, such as occurs when lava flows on land, tends to produce fine grained rock such as basalt. Molten material cooled within the earth at slow rates tends to consist of large grain rock such as granite.

04 Sedimentary rock results when sediments are deposited by wind, water, or glaciers, or by direct precipitation of dissolved material in water. Sandstone is an example of mechanically deposited rock, while limestone is an example of chemically created rock.

05 Metamorphic rocks result from the “re-working” of existing rock (either igneous, sedimentary, or older metamorphic) under the influence of high temperatures and pressures within the earth. Quartzite is metamorphized sandstone, while marble is metamorphized limestone.

All three classes of rock have been used as aggregates in road construction. The suitability of aggregate from a given source must be determined from a combination of tests and mineralogical examinations.

06 Precise, standard methods of sampling and testing are essential to obtaining results that correctly describe the characteristics of the aggregate. Depending on the characteristics, the aggregate may be used for road base, concrete, or hot mix asphalt.



08

Angular vs. rounded

Properties

Physical, chemical, and mechanical properties influence the suitability of aggregate for roadway construction. Physical properties include particle shape, particle size, size distribution, surface texture, absorption, specific gravity, unit weight, and void content. Chemical or electrochemical properties encompass solubility, reactivity with or resistance to attack by other chemicals, and affinity to asphalt cement. Mechanical properties include resistance to effects of applied traffic loads.

Table 1 summarizes basic properties of aggregate relative to three specific uses:

- Base – Aggregate Base Course
- PCC – Portland Cement Concrete
- HMA – Hot Mix Asphalt

Summary

A knowledge and understanding of the characteristics, and the test methods used to determine these characteristics, are essential to the quality of concrete and HMA. It is also critical where aggregate is used in road base and embankment. As sources for aggregates are diminished, more emphasis on making the most of current resources is necessary.

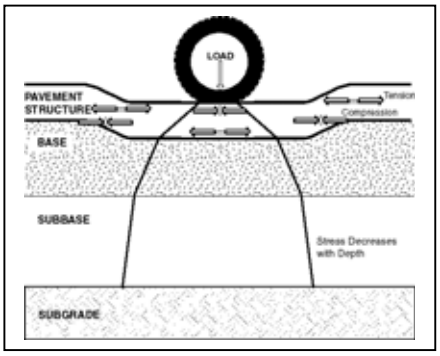
Table 1
Effects of Aggregate Properties on Base, PCC, and HMA

	Effect on Material Produced		
Aggregate Property	**Base**	**PCC**	**HMA**
Grading – general	Impacts workability, density, strength, stability	Impacts workability, density, strength, stability	Impacts workability, density, strength, stability
Dense grading	Required for strength and stability	Not commonly used	Commonly used
Gap grading	May be OK	Commonly used	May be OK
Open grading	Good for drainage, poor for strength	Poor choice	May be OK
Rounded and rough	Poor interlocking causes weakness	Good for normal use	Good adhesion, poor interlocking
Rounded and smooth	Poorest choice	Lowers bond but good for normal use	Poorest choice
Angular and smooth	Acceptable	Lower bond may result	Good interlocking, poor adhesion
Angular and rough	Best for normal use	Workability will be poor, but high strength will result	Good adhesion, good interlocking
Flakiness	Weak base material	Weak mix may result	Bridging (high voids and low strength), may degrade
Porosity	Susceptible to frost action	Reduces bond and freeze/thaw resistance, lowers strength	Excessive values cause high binder absorption, reduces durability
Specific gravity	Related to toughness	Required for mix design calculations, related to toughness	Required for mix design calculations, related to toughness
Cleanliness	Impurities, dust increase frost susceptibility	Impurities, dust reduce adhesion	Impurities, dust reduce adhesion
Toughness	Critical to strength	Usually not important	Critical to mix stability
Chemistry	Usually not important	Alkali-silica reactivity is serious concern	Electrochemical charge of aggregates must be matched with appropriate binders

BASICS OF COMPACTION AND DENSITY CONTROL

01

Introduction



Load distribution in roadway cross section

02

Roadways are constructed in layers. The first layer is the subgrade, or naturally present material. Next comes the subbase, material usually having better

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structural, drainage, and other properties than the subgrade. This material is sometimes a select material. Above the subbase is placed the base, material of even better quality than the subbase. Finally there is the pavement consisting of either hot mix asphalt (HMA) or portland cement concrete (PCC). In this layered system, structural or load bearing properties improve as we move up from subgrade to pavement. The result is a roadway structure that supports traffic without undergoing excessive surface deflection and/or long term settlement.

Variations to this layering can occur as in roadways constructed on high quality subgrade in which the subbase layer is eliminated. Also to be considered is “embankment”, material between the naturally occurring subgrade and the subbase or base, that is added in “fill” sections of the roadway where the finished road is substantially above original grade.

Grading

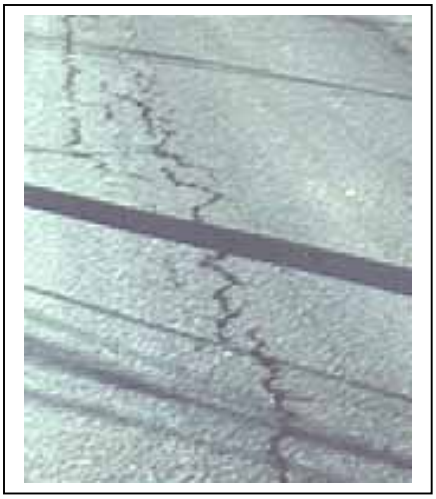
04

Stability and durability of roadways is greatly dependent on the finished density of the various components. Low-density subgrade, subbase, base,

05

or embankment will lead to excessive surface deflection under load and/or long term settlement in an amount higher than anticipated. However, compacting these elements to densities higher than necessary is expensive in both time and money.

Quality of roadways also depends greatly on the pavement. In HMA roadways, the density of the HMA plays a significant role in the overall ability to support load and provide long term service. HMA pavement specifications include detail on density as well as percent voids. Under-compaction



Cracking

Sheepsfoot roller

Steel roller

results in low density and high void content. An under-compacted pavement will have low strength, reduced durability, high deformation, and high permeability leading to problems such as rutting, ravelling, and freeze-thaw damage. Over-compaction results in high density and low void content. This pavement may bleed, rut, crack, or have premature failure.

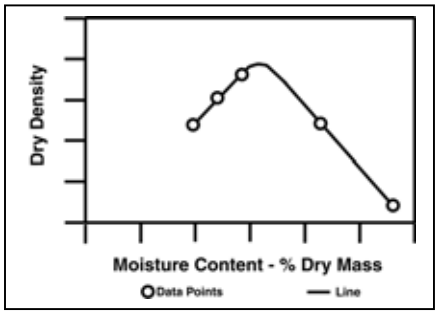
For these reasons, a basic understanding of compaction theory and a thorough knowledge of testing methods is necessary for those involved with construction of embankments and bases, as well as HMA pavement. Compaction equipment and techniques depend on the type of material. Cohesive soils, such as clay, and cohesionless soils, such as gravel, require different compaction methods, and different equipment may be used on HMA than on soils.

Fine-Grained Soils

For fine-grained soils that contain a significant amount of cohesion and little or no internal friction, density depends on compactive effort and moisture content. With these soils, moisture-density relations are key, and two similar test methods are used to determine the relationship between soil moisture and density.

- AASHTO T 99, the standard Proctor test
- AASHTO T 180, the modified Proctor test

In both methods, samples of soil are prepared at several moisture contents and compacted into molds of specified sizes using manual or mechanical rammers delivering a specified quantity of compactive energy. Knowing the moist masses of the compacted samples and the volume of the molds, moist densities can be determined. Moisture contents of the compacted samples are determined and used to obtain dry density values for the same samples. Maximum dry density and optimum moisture content for the soil are determined by plotting the relationship between dry density and moisture content.



Moisture-density curve

Construction specifications generally require that the soil be compacted to some percentage of maximum dry density while being maintained at a moisture content close to the optimum. These specified values will be based on AASHTO T 99 or AASHTO T 180 depending on the agency. In the field, dry density and moisture content of the material will be determined using a nuclear moisture-density gauge. The field values will be compared to the specifications to determine conformance with the project requirements.

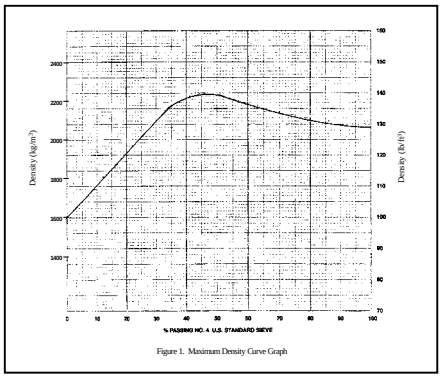
Coarse-Grained Soils

Nuclear moisture-density gauge

For coarse-grained granular soils having little or no cohesion, compactive effort is the primary concern, and moisture content is not as significant an issue because these soils are free-draining and do not retain water. These soils are tested using two general classifications of procedures. The first includes the moisture-density methods discussed above under "Fine-grained Soils." The second includes procedures that relate density to gradation.

Granular, free-draining materials can be tested by procedures that combine compaction and vibration, as in the Relative Density test. However, various transportation agencies have developed specialized tests that are a hybrid of moisture-density test procedures and relative density determinations, including the following:

- AKDOT&PF's ATM-12
- ITD's T-74
- WSDOT's TM 606
- WFLHD's Humphrys



Maximum density curve

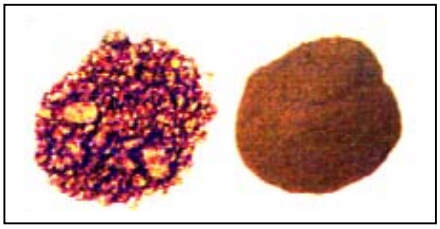
In these tests, material is compacted in a mold and in a manner similar to those used in a Proctor test, after which the material is further compacted through a combination of applied loads and vibration. A laboratory maximum dry density is determined, as is the percent of material passing a certain sieve such as the 4.75 mm (No. 4). A number of determinations are made for different percentages passing the specified sieve. A graph is developed in which dry density is plotted versus the

percentage of material passing that sieve. These
21 tests are conducted in the agency's central lab, and the curve developed is a central lab function.

Construction specifications will call out a percent of maximum dry density required for the granular materials used on the job. These specified values will be based on ATM-12, T-74, TM 606, and Humphry's depending on the agency. In the field, the density of the granular material will be determined using a nuclear moisture-density gauge. The percent of material passing the specified sieve will also be determined. These values will be compared with the curve developed in the lab to determine conformance with the project specifications.

Correction for Oversize Material

22 AASHTO T 99, and AASHTO T 180 discussed above are conducted on materials below a certain size, either 4.75 mm (No. 4) or 19.0 mm (3/4-in.) depending on the method. If the material to be
23 tested includes particles in excess of that size, corrections will be required to the maximum dry densities determined. The method used is AASHTO T 224, Correction for Coarse Particles in the Soil Compaction Test.

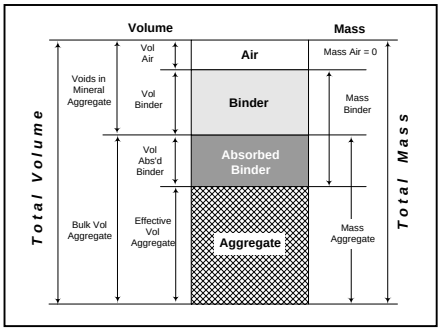


Coarse and fine material

The corrected density is actually a weighted average of the density of the smaller material passing the specified sieve and the larger material retained on the sieve. The density of the smaller material is determined using one of the methods covered above. The density of the larger material is based on knowledge of its bulk specific gravity.

Hot Mix Asphalt Pavement

24 For HMA, density depends on compactive effort as well as the mix design. The gradation and particle shape of the aggregate, the grade of asphalt binder, and the interaction of these have major influences on density and percent voids. The level of compactive effort and the equipment used depend



HMA phase diagram

on the mix design properties, environmental conditions and lift thickness.

25 Construction specifications will call for obtaining a certain percentage of maximum voidless density, as determined in the mix design process, while maintaining voids within a certain range. A specification of 92 to 96 percent of maximum density and a corresponding void content between 8 and 4 percent is typical. In the field, the density of the compacted HMA will be determined with cores and/or calibrated nuclear density gauges and, with this information, the percent voids will be calculated. These values will be compared to the specifications to determine conformance with the project requirements.

26

Summary

27 Proper compaction of soil, aggregate, and hot mix asphalt is necessary for high-quality roadways. Understanding and proper performance of standardized density tests are paramount in obtaining that compaction. The Embankment and Base and/or In-Place Density technician must obtain samples and perform tests in the accepted manner in order to assure the quality of the finished roadway.

BASICS OF ASPHALT

01

Introduction

02

Slice through asphalt core

Asphalt cement concrete (ACC) is a mixture of two primary ingredients: mineral aggregate and asphalt cement (AC) or asphalt binder as it is now termed. The binder holds the aggregate together in a moderately flexible rock-like mass. Hot mix

03

asphalt (HMA) includes mixes that are produced at an elevated temperature. ACC and HMA are generally divided into three types of mixes, depending on the gradation of aggregate: dense-graded, open-graded, and gap-graded.

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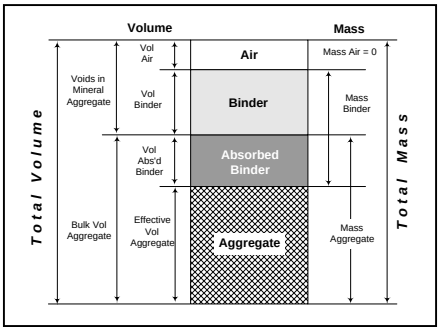
Dense-graded HMA consists of binder and well-graded aggregate evenly distributed from small to large particles. Open-graded HMA consists primarily of coarse aggregate, minimal fine aggregate, and binder. The mixture provides a very open surface texture — one that allows water to drain into the mix and in which large aggregate, stone-to-stone contact handles the load of a vehicle traveling over the surface. Gap-graded HMA is similar to open-graded mix, except that mid-size aggregate between the 4.75 mm (No. 4) and 425 µm (No. 40) sieves is missing or present only in small amounts.



HMA phase diagram

HMA contains air voids in addition to aggregate and binder. Also, the binder is divided into two

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categories: absorbed (into the aggregate) and effective (which remains on the surface for binding aggregate particles together).

06

Five factors affect pavement performance: structural design of pavement layers, mix design properties, workmanship used to produce, place, and compact the mix, loading factors, and environmental conditions. The best specifications, if not followed, will not assure a high quality, long-lasting pavement. The best mix design, if not duplicated at the plant, will not guarantee the life of the pavement. The most sophisticated equipment, if not operated properly, will not produce a roadway that withstands the effects of traffic and the environment. Poor workmanship can negate all those items and cause premature failure of pavement materials and / or pavement structure.

High quality materials testing and construction inspection are critical to a successful project.

Design Parameters

Whether a mix design is developed through a
07 Marshall, Hveem, or Superpave mix design process there are basic volumetric requirements of all. Volumetrics can include Bulk specific gravity,
08 theoretical maximum specific gravity, air voids, and voids in mineral aggregate.
09

The total mass of the mix includes entrapped air, moisture, effective and absorbed binder, and mineral aggregate. This total mass divided by the corresponding bulk or total volume of a specimen yields a number known as bulk density. Bulk density is calculated by determining the bulk specific gravity, G_{mb}, of the sample and multiplying by the density of water.

There are two procedures for calculating G_{mb} –
10 suspension and volumeter. In the suspension procedure, G_{mb} is calculated as follows.

$$G_{mb} = \frac{A}{B - C}$$

where:

G_{mb} = Bulk specific gravity
A = Mass of dry, compacted specimen in air
B = Mass of saturated surface dry (SSD) compacted specimen in air
C = Weight of compacted specimen in water at 25°C (77°F)

The combined masses of binder and aggregate
11 divided by the volume of these components only is the maximum density. This density is “maximum” in that it contains no air voids. The maximum density provides a reference or base used to determine the amount of air actually present in the mix, among other things. Maximum density is determined on uncompacted HMA by determining

the theoretical maximum specific gravity, G_{mm}, and multiplying by the density of water.

There are two procedures for calculating G_{mm} – bowl and flask. In the flask procedure, G_{mm} is
12 calculated as follows.

$$G_{mm} = \frac{A}{A + D - E}$$

where:

G_{mm} = Theoretical maximum specific gravity
A = Mass of dry specimen in air
D = Mass of flask filled with water at 25°C (77°F)
E = Mass of flask filled with water and specimen at 25°C (77°F)

13 Air voids are expressed as a percentage of total sample volume. Percent air voids, V_a, is calculated as follows.

$$V_a = ((G_{mm} - G_{mb})/G_{mm}) \times 100$$

where:

V_a = Percent air voids of total mix mass
G_{mb} = Bulk specific gravity of compacted mix
G_{mm} = Theoretical maximum specific gravity

14 Voids between aggregate particles may contain air or binder. Voids in the mineral aggregate, VMA, are those spaces in laboratory compacted specimens that include air and effective, but not absorbed, binder.

15

$$VMA = 100 - \left[\frac{(G_{mb} P_s)}{G_{sb}}\right]$$

where:

VMA = Voids in the mineral aggregate
G_{mb} = Bulk specific gravity of compacted mix
G_{sb} = Bulk specific gravity of aggregate
P_s = Percent aggregate content in mix by mass of total mix

16 Finally, the voids filled with asphalt (VFA) is

expressed as the percentage of the VMA that contains asphalt.

$$VFA = ((VMA - V_a) / VMA) \times 100$$

where:

VFA = Voids filled with asphalt
VMA = Voids in the mineral aggregate
V_a = Percent air voids by total mass of mix

The above parameters are used in developing HMA mix design. These items should be systematically monitored during construction to ensure a quality product.

Asphalt Cement Binder

17

In the past, asphalt cement (AC) was graded by either penetration (AASHTO M 20) or viscosity (AASHTO M 226). Penetration graded asphalts were specified by a measurement by a standardized penetrometer needle under a standard load at a standard temperature. Penetration graded asphalts were typically expressed as "Penetration Grade 85-100", meaning that the needle penetration was between 85 and 100 millimeters. The higher the penetration, the softer the AC.

Viscosity graded asphalts were specified by determining the viscosity of AC. A temperature of 60°C (140°F) was considered to be a typical summer pavement temperature, and at this temperature, the unit of viscosity used was the poise. Standard terminology referred to AC-10 and AC-20, meaning that the viscosity of the AC was 1000 or 2000 poise, respectively. AC-20 was thicker or harder than AC-10. A temperature of 135°C (275°F) was considered the mixing and handling control point. At this temperature, different laboratory equipment was used and the unit of viscosity used was the centistoke (Cs).

In 1994, the industry formally accepted and began to implement years of research done under the Strategic Highway Research Program (SHRP). SHRP developed a new system of design for asphalt paving materials known as Superpave™. A

new concept calling for performance grading was introduced.

18 Performance Graded (PG) asphalt binders were introduced experimentally in 1994 and industry now uses PG specifications. The PG system of specifying binder is based on a complex series of performance based tests. The new specification system no longer refers to asphalt cement, but rather to binder, which includes modified and unmodified asphalts.

The new system specifies asphalt binders as PG followed by two numbers, for example PG 64-22. The first number is always higher and positive, while the second number is smaller and negative. The first number represents the expected average 7-day high pavement temperature, while the second number represents the expected single low pavement temperature. Both numbers referred to are in degrees Celsius.

Types of Manufacturing Plants

19 Two common types of plants are drum plants and batch plants. Both types are capable of producing the same quality HMA. One is not better than the other. These plants are similar in that both have cold feed systems for aggregate. Material of different sizes is dropped from bins onto belts, transported to a mixer, blended, and then dropped onto another belt for transport to the dryer. The plants are different in the means of production following heating in the dryer.

Aggregate feed bins

20 **Drum Plants** – In drum plants, scales under the belts from each bin control the mass flow rate of
21 each aggregate size. Moisture corrections are applied in order to base the process on dry mass. Binder flow rate is controlled by a metered delivery pump. Aggregate and binder are mixed in the far end (near the exit) of the drum and then stored temporarily in a silo.

With a drum plant supplying HMA to a single project, the aggregate and binder, as measured by the scales and meter, can be compared with the material delivered to the job. After accounting for waste and reject, binder quantity, as measured by

field tests, should agree within 1 percent with the quantity metered at the plant. The total mass of the aggregate and binder measured at the plant should agree within 2 percent of total mass delivered to the site as measured by the platform scales over which the delivery trucks pass.

Drum plants are typically used for large jobs and are more portable. Drum plants continuously feed aggregate and binder into the drum, and produce large quantities of HMA during the course of a run. Drum plants, however, cannot switch mix designs with ease and require close control of material being fed to the dryer. Drum plants produce the same mix over an extended period, not several different mixes in a day as with batch plants.

Aggregate feed

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Batch Plants – In batch plants, aggregate is rescreened and stored in separate bins after drying. Aggregate is taken from each bin on the basis of the mass called for in the mix design – the mass being determined in the aggregate hopper. A separate hopper is used for determining the mass of the binder. Aggregate and binder are mixed in a chamber, or pugmill, and then dropped into a truck or stored temporarily in a silo.

Batch plants are used where different mix designs are often needed. Batch plants are less efficient than drum plants because they only mix a certain amount of HMA at a time. They are more flexible, however, because several mixes can be made in a day. In fact, a batch plant can switch from one mix to another fairly quickly, as long as both mixes use aggregates from the same source.

Summary

23

High quality hot mix asphalt requires a proper combination of materials and workmanship. The testing technician plays a critical role in helping assure that materials incorporated into a roadway meet the requirements of the proper specification. No amount of proper workmanship can compensate for poor material quality.

SAMPLING OF AGGREGATES FOP FOR AASHTO T 2

Sampling aggregate

01

Significance

Tests cannot be performed on all the material included in an entire project, so samples are taken from the whole. Proper material sampling is critical to all subsequent testing. If the representative

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portion obtained through sampling does not truly represent the material, any analysis of that portion is

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inappropriate for the project at hand. Since only a portion of the whole is used, that portion must be a reliable reflection of the whole. The size of the sample will depend upon the tests to be run and on the nominal maximum size of the aggregate.

Scope

This procedure covers sampling of fine and coarse aggregates (FA and CA) in accordance with AASHTO T 2. Sampling from conveyor belts, transport units, roadways, and stockpiles is covered.

The specifications for some materials may require the contractor to provide a mechanical sampling system at crushers, screening operations, and mixing plants. This system is normally a permanently attached device that allows a sample container to pass perpendicularly through the entire stream of material or diverts the entire stream of material into the container. The sample container is normally larger at the bottom than the top (trapezoidal shaped), with the opening in the top based on the size of aggregate being sampled.

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Operation may be hydraulic, pneumatic, or manual, and shall allow the sample container to pass through the stream at least twice, once in each

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direction, without overfilling. With manually operated systems, a consistent operating speed is difficult to maintain and may result in variably sized, non-representative samples. For this reason, some agency specifications require that the

sampling device be automatic or semi-automatic.

Apparatus

06

Apparatus

Shovels, scoops, sampling tubes of acceptable dimensions.

- Custom built sampling devices or templates suitable for varied sampling scenarios, and sampling containers.

Procedure - General

Sampling is as important as testing, and the technician shall use every precaution to obtain samples that will show the true nature and condition of the materials the sample represents.

07 1. Wherever samples are taken, obtain multiple increments of approximately equal size.

08

08 2. Mix the increments thoroughly to form a field sample that meets or exceeds the minimum mass recommended in Table 1.

Note 1: Based upon the tests required, the sample size may be four times that shown in Table 1 of the FOP for AASHTO T 27/T 11, if that mass is more appropriate. As a general rule the field sample size should be such that, when split twice will provide a testing sample of proper size.

Belt Sampler

TABLE 1
Sample Sizes

Nominal Maximum Size* in.	Minimum Mass g	(lb)
No. 8	10,000	(25)
No. 4	10,000	(25)
3/8	10,000	(25)
1/2	15,000	(35)
3/4	25,000	(55)
1	50,000	(110)
1½	75,000	(165)
2	100,000	(220)
2½	125,000	(275)
3	150,000	(330)
3½	175,000	(385)

* One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained. Where large gaps in specification sieves exist, intermediate sieve(s) may be inserted to determine nominal maximum size. Maximum size is one sieve larger than nominal maximum size.

Nominal maximum size and maximum size are <u>not</u> the same.

Example:

Sieve Size, in	C**umulativePercent Retained**
3	0
2½)	0
2	0
1½	7
1	32
3/4	38
1/2	47
3/8	58
No.4	72

First sieve to cumulatively retain >10 percent: 1”
Nominal maximum size: 1½
Maximum size: 2’’

Sampling from the belt

Procedure – Specific Situations

In all situations, determine the time or location for sampling in a random manner.

A. Conveyor Belts

Avoid sampling at the beginning or the end of an aggregate run due to the potential for segregation.

Method A (From the Belt): Stop the belt. Set the sampling device in place on the belt, avoiding intrusion by adjacent material. Scoop off the sample, including all fines. Obtain a minimum of three increments.

Method B (From the Belt Discharge): Pass a sampling device through the full stream of the material as it runs off the end of the conveyor belt. The sampling device may be manually, semi-automatic or automatically powered. The sample container shall pass through the stream at least twice, once in each direction, without overfilling while maintaining a constant speed during the sampling process.

Sampling from windrow

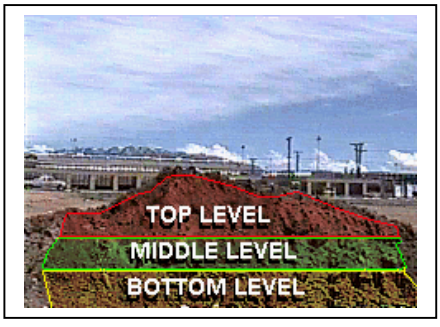
B. Transport Units

Visually divide the unit into four quadrants. Identify one sampling location in each quadrant. To avoid surface segregation, dig down and remove approximately 1 ft of material. Obtain each increment from below this level . Combine the increments to form a single sample.

C. Roadways

Randomly locate three sample locations. Obtain increments of approximately equal size from each location. Take the full depth of the layer to be sampled, being careful to exclude the underlying material. Combine the increments to form a sample.

Note 2: If from a berm or windrow the entire cross-section must be sampled after the last mixing pass and prior to spreading and compacting. This may yield extra large samples and may not be the preferred sampling location. Do not sample from the beginning or the end of a berm or windrow.



Top, middle, bottom

D. Stockpiles

Note 3: Sampling at stockpiles should be avoided whenever possible due to problems involved in obtaining a representative gradation of material.

1. Create, with a loader if one is available, horizontal surfaces with vertical faces in the top, middle, and bottom third of the stockpile. When no equipment is available, a shovel may be used to create horizontal surfaces with vertical faces.
2. Prevent sloughing by shoving a flat board in against the vertical face. Sloughed material will be discarded to create the horizontal surface. Sample from the horizontal surface at the intersection of the horizontal and vertical faces. Take at least one increment

from each of the top, middle, and bottom thirds of the pile and combine.

When sampling sand, remove the outer layer that may have become segregated. Using a sampling tube, obtain material from five random locations on the pile and mix thoroughly to form one sample.

30

Tips!

32

- Remember, the sample must be representative of the whole.
- And, the sample must be selected at random to avoid bias.
- Automatic mechanical sampling is preferred.

REVIEW QUESTIONS

1. How can power equipment, such as loaders and backhoes, be used to collect aggregate samples?

2. Describe the process for sampling from a conveyor belt using method “A”.

3. Which sampling location should be avoided whenever possible due to problems involved in obtaining a representative gradation of material?

4. Describe sampling from roadways.

PERFORMANCE EXAM CHECKLIST (ORAL)

SAMPLING OF AGGREGATES
FOP FOR AASHTO T 2

Participant Name _____ Exam Date _____

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	**Trial 1**	**Trial 2**
1. How is a sample obtained from a conveyor belt using method A?		
a) Stop the Belt.	_____	_____
b) Set the Sampling device on belt, avoiding intrusion of adjacent material.	_____	_____
c) All the material is removed from belt including all fines.	_____	_____
a) Take at least three equal increments.	_____	_____
2. How is a sample obtained from a conveyor belt using method B		
a) Pass the sampling device through full stream of material as it runs off end of the belt.	_____	_____
b) The device must be passed through at least twice (once in each direction).	_____	_____
3. How is a sample obtained from a transport unit?		
a) Divide the unit into four quadrants.	_____	_____
b) Dig 1 ft. below surface.	_____	_____
c) Obtain an increment from each quadrant.	_____	_____
4. Describe the procedure for sampling roadways?		
a) Sample the material full depth without obtaining underlying material.	_____	_____
b) Take at least three equal increments.	_____	_____
5. Describe the procedure for sampling a stockpile.		
a) Create vertical faces and at least one increment taken from each of the top, middle, and bottom thirds of the stockpile.	_____	_____
6. Describe the procedure for sampling a sand stockpile.		
a) Remove the outer layer and increments taken from at least five locations.	_____	_____
7. After obtaining the increments what should you do prior to performing T248?		
a) Increments mixed thoroughly to form sample?	_____	_____

Comments: First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

_____

_____

_____

Examiner Signature _____WAQTC #:_____

REDUCING SAMPLES OF AGGREGATES TO TESTING SIZE FOP FOR AASHTO T 248

Significance

Aggregates and other materials sampled in the field in accordance with AASHTO T 2 are large composites and need to be reduced to the appropriate size for testing. It is extremely important that the procedure used to reduce the field sample not modify the material.

Scope

This procedure covers the reduction of samples to the appropriate size for testing in accordance with AASHTO T 248. Techniques are used that minimize variations in characteristics between test samples and field samples. Method A (Mechanical Splitter) and Method B (Quartering) are covering.

This procedure applies to fine aggregate (FA), coarse aggregate (CA), and mixes of the two, and may also be used on soils.

Samples of FA that are drier than the saturated surface dry (SSD) condition shall be reduced by a mechanical splitter according to Method A. Samples of FA that are at SSD or wetter shall be reduced by Method B, or the entire sample may be dried to the SSD condition, using temperatures that do not exceed those specified for any of the tests contemplated, and then reduced to test sample size using Method A. Samples of CA or mixtures of FA and CA may be reduced by either method. As a quick determination, if the fine aggregate will retain its shape when molded with the hand it is wetter than SSD.

Mechanical splitter

Quartered sample

Mechanical splitter

Apparatus

Method A – Mechanical Splitter

Splitter chutes:

- Even number of equal width chutes
- Discharge alternately to each side
- Minimum of 8 chutes total for CA, 12 chutes total for FA
- Width
    - Minimum 50 percent larger than largest particle
    - A maximum chute width of 3/4 in. for fine aggregate passing 3/8 in. sieve
- Feed Control
    - Hopper or straightedge pan width equal to or slightly less than the overall width of the assembly of chutes.
    - Capable of feeding the splitter at a controlled rate.
- Splitter Receptacles / Pans:
    - Capable of holding two halves of the sample following splitting.

The splitter and accessory equipment shall be so designed that the sample will flow smoothly without restriction or loss of material.

Method B – Quartering

- Straightedge scoop, shovel, or trowel
- Broom or brush
- Canvas or plastic sheet, approximately 6 by 9 ft

Sample Preparation

If the FA sample is wetter than the SSD condition and Method A – Mechanical Splitter is to be used, dry the material using temperatures not exceeding those specified for any of the tests contemplated for the sample.

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Note 1: It may be undesirable to split some FA / CA mixtures that are over SSD condition using Method A.

Procedure

Method A Mechanical Splitter

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Mechanical splitter

1. Place the sample in the hopper or pan and uniformly distribute it from edge to edge so that approximately equal amounts flow through each chute. The rate at which the sample is introduced shall be such as to allow free flowing through the chutes into the pans below.

2. Split the sample from one of the two pans as many times as necessary to reduce the sample to the size specified for the intended test. The portion of the material collected in the other pan may be reserved for reduction in size for other tests. As a check for effective splitting, determine the mass of each part of the split. If the ratio of the two masses differs by more than 5 percent, corrective action must be taken.

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Calculation

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Splitter check: 5127 total sample mass

Splitter pan #1: 2583

Splitter pan #2: 2544

$$\frac{2544}{2583} \text{X}100 = 98.5 \qquad 100\text{-}98.5 = 1.5\%$$

Method B – Quartering

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Use either of the following two procedures or a combination of both.

Procedure #1: Quartering on a clean, hard, level surface:

1. Place the sample on a hard, clean, level surface where there will be neither loss of material nor the accidental addition of foreign material.
2. Mix the material thoroughly by turning the entire sample over a minimum of three times. With the last turning, shovel the entire sample into a conical pile by depositing each shovelful on top of the preceding one.
3. Flatten the conical pile to a uniform thickness and diameter by pressing down with a shovel. The diameter should be four to eight times the thickness.
4. Divide the flattened pile into four approximately equal quarters with a shovel or trowel.
5. Remove two diagonally opposite quarters, including all fine material, and brush the cleared spaces clean.
6. Successively mix and quarter the remaining material until the sample is reduced to the desired size.
7. The final test sample consists of <u>two diagonally opposite</u> quarters.

Flattening pile

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Dividing pile

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Mixing the sample

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Quartered sample

Procedure #2: Quartering on a canvas or plastic sheet:

1. Place the sample on the sheet.
2. Mix the material thoroughly by turning the entire sample over a minimum of three times. Lift each corner of the sheet and pulling it over the sample toward the diagonally opposite corner, causing the material to be rolled. With the last turning, form a conical pile.
3. Flatten the conical pile to a uniform thickness and diameter by pressing down with a shovel. The diameter should be four to eight times the thickness.
4. Divide the flattened pile into four approximately equal quarters with a shovel or trowel, or, insert a stick or pipe beneath the sheet and under the center of the pile, then lift both ends of the stick, dividing the sample into two roughly equal parts. Remove the stick leaving a fold of the sheet between the divided portions. Insert the stick under the center of the pile at right angles to the first division and again lift both ends of the stick, dividing the sample into four roughly equal quarters.
5. Remove two diagonally opposite quarters, being careful to clean the fines from the sheet.
6. Successively mix and quarter the remaining material until the sample size is reduced to the desired size.
7. The final test sample consists of <u>two diagonally opposite</u> quarters.

Tips!

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- Remember, the reduced sample must be representative of the whole.
- Method A – mechanical splitter – is preferred.
- Method A cannot be used for FA wetter than SSD condition.
- Keep the mechanical splitter dry to avoid having particles "stick" to it.
- Make sure your splitter is level

REVIEW QUESTIONS

1. When using the mechanical splitter for FA, the minimum width of the individual chutes should be approximately how much larger than the largest particles in the sample to be split?

2. What is the maximum width for material passing the 3/8 in sieve?

3. How does the moisture content of the sample influence reduction?

4. Define the SSD condition.

5. Describe two methods of mixing the sample.

PERFORMANCE EXAM CHECKLIST

REDUCING FIELD SAMPLES OF AGGREGATES TO TESTING SIZE FOP FOR AASHTO T 248

Participant Name _____ Exam Date _____

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

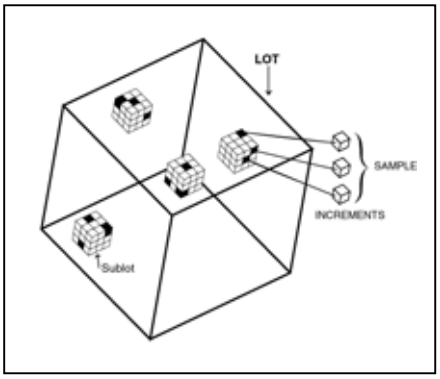
	Trial 1	Trial 2
Method A - Splitting		
1. Material spread uniformly on feeder?	_____	_____
2. Rate of feed slow enough so that sample flows freely through chutes?	_____	_____
3. Material in one pan re-split until desired mass is obtained?	_____	_____
Method B - Quartering		
1. Sample placed on clean, hard, and level surface?	_____	_____
2. Mixed by turning over 3 times with shovel or by raising canvas and pulling over pile?	_____	_____
3. Conical pile formed?	_____	_____
4. Diameter equal to about 4 to 8 times thickness?	_____	_____
5. Pile flattened to uniform thickness and diameter?	_____	_____
6. Divided into 4 equal portions with shovel or trowel?	_____	_____
7. Two diagonally opposite quarters, including all fine material, removed?	_____	_____
8. Cleared space between quarters brushed clean?	_____	_____
9. Process continued until desired sample size is obtained when two opposite quarters combined?	_____	_____

*The sample may be placed upon a sheet and a stick or pipe may be placed under the sheet to divide the pile into quarters***.**

Comments: First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

Examiner Signature _____ WAQTC #:_____

SAMPLING OF BITUMINOUS PAVING MIXTURES
FOP FOR AASHTO T 168



Sampling from a lot

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Significance

Testing bituminous paving mixtures in the field begins with obtaining and preparing the sample to be tested. Standardized procedures for obtaining a representative sample have been established. Producing strong, durable, reliable pavement in roadways requires careful sampling and accurate testing.

Technicians must be patient and follow these procedures. If one considers that the specifications require quality tests to be made on only a small portion of the total material placed, the need for a truly representative sample is apparent.

02

HMA sample

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Scope

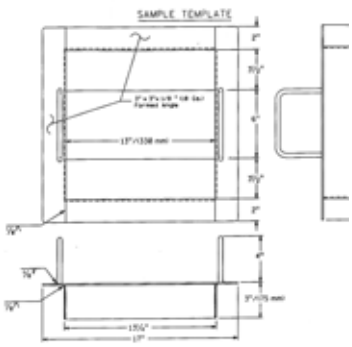
This procedure covers the sampling of bituminous paving mixtures from HMA plants; haul units, and roadways, in accordance with AASHTO T 168.

Sampling is as important as testing, and every precaution must be taken to obtain a truly representative sample.

04

Apparatus

- Shovel
- Sample containers: such as cardboard boxes, metal cans, stainless steel bowls, or other agency-approved containers
- Belt template to match conveyor belt shape
- Scoops, trowels, or other equipment to obtain mix
- Sampling plate: heavy gauge metal plate 15 in x 15 in minimum 8 gauge thick with a wire attached to one corner long enough to reach



Cookie Cutter Sampling Device

from the center of the paver to the outside of the farthest auger extension. Holes ¼" in diameter should be provided in each corner.

- Cookie cutter sampling device: A 13 in. square sampling template, constructed from 3 in. x 2 in. x 1/8 in. formed steel angle with two 4 in. x 6 in. x 3/8 in. handles. See diagram

  Note 1: Sampling Plate and Cookie cutter may be sized appropriately to accommodate sample size requirements.

- Mechanical sampling device

Sample Size

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Sample size depends on the test methods specified by the agency for acceptance. Check agency requirement for the size required.

Sampling

General

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1. The material shall be tested to determine variations. The supplier/contractor shall provide equipment for safe and appropriate sampling including sampling devices on plants, when required.
2. Place dense graded mixture samples in cardboard boxes, stainless steel bowls or other agency approved containers. Place open graded mixture samples in stainless steel bowls. Do not put open graded mixture samples in boxes until they have cooled to the point that bituminous material will not migrate from the aggregate.

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3. Sampling from the Roadway will require the contractor to repair the sampled location.

   Note 2: *Care shall be taken to prevent contamination of bituminous mixes by dust or other foreign matter, and to avoid segregation of aggregate and bituminous materials.*

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Sampling from a Conveyor Belt

1. Stop the conveyor belt.
2. Select at least three areas locations of approximately equal increments that will form a sample of the required size when combined.
3. Insert belt template in each of the locations to be sampled.
4. Scoop all material inside template into a suitable container.

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Attached Sampling Devices

Attached Sampling device

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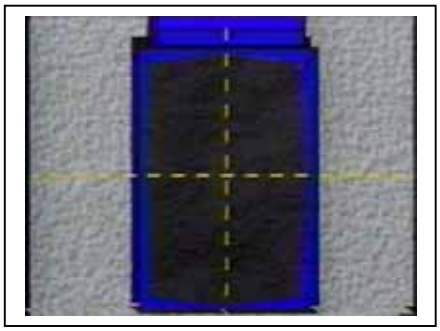
Some agencies require mechanical sampling devices for hot mix asphalt (HMA) and cold feed aggregate on some projects. These are normally permanently attached devices that allow a sample container to pass perpendicularly through the entire stream of material or divert the entire stream of material into the container. Operation may be hydraulic, pneumatic, or manual and allows the sample container to pass through the stream twice, once in each direction, without overfilling. Special caution is necessary with manually operated systems since a consistent speed is difficult to maintain and non-representative samples may result. Check agency requirements for the specifics of required sampling systems.

1. When using an attached sampling device, pass the container twice through the material perpendicularly without overfilling the container.
2. Repeat until proper sample size has been obtained.



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Quadrants in a load

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Plate on untreated base

Sampling from Haul Units

1. Visually divide the haul unit into approximately four equal quadrants.
2. In each quadrant, remove and discard approximately 12 in. of material and obtain samples.
3. Combine the increments to form a sample of the required size.

Sampling from Roadway Prior to Compaction (Plate Method)

Plate Method using the "cookie cutter" sampling device.

There are two conditions that will be encountered when sampling Hot Mix Asphalt (HMA) from the roadway prior to compaction. The two conditions are:

1. Laying HMA on grade or untreated base material requires Method 1.
2. Laying HMA on existing asphalt or laying a second lift of HMA requires Method 2.

Cookie cutter and plate can be sized according to test sample needs.

SAFETY:

Sampling is performed behind the paving machine and in front of the breakdown roller. For safety, the roller must remain at least 10 ft behind the sampling operation until the sample has been taken and the hole filled with loose HMA.

Method 1 requires a plate to be placed in the roadway in front of the paving operation. There is always concern when working in the path of moving equipment. It is safest to stop the paving train while a plate is installed in front of the paver. When this is not possible the following safety rules must be followed.

1. The plate placing operation must be at least 10 ft in front of the paver or pickup device. The technician placing the plate must have eye contact and communication with the paving machine operator. If eye contact cannot be maintained at all time, a third person must be present to provide communication between the operator and the technician.
2. No technician is to be between the asphalt supply trucks and the paving machine. The exception to this rule is if the supply truck is moving forward creating a windrow, in which case the technician must be at least 10 ft behind the truck.
3. At any time the Engineer feels that the sampling technique is creating an unsafe condition, the operation is to be halted until it is made safe or the paving operation will be stopped while the plate is being placed.

Method 1 - Obtaining a Sample on Untreated Base:

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1. Following the safety rules detailed above, the technician is to:
    a. Smooth out a location in front of the paver at least 2 ft inside the edge of the mat.
    b. Lay the plate down diagonally with the direction of travel, keeping it flat and tight to the base with the lead corner

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facing the paving machine.

2. Secure the plate in place with a nail through the hole in the lead corner of the plate.
3. Pull the wire, attached to the outside corner of the plate, taut past the edge of the HMA mat and secure with a nail.
4. Let the paving operation proceed over the plate and wire. Immediately proceed with the sampling.
5. Using the exposed end of the wire, pull the wire up through the fresh HMA to locate the corner of the plate. Place the "cookie cutter" sampling device, just inside the end of the wire; align the cutter over the plate. Press "cookie cutter" device down through the HMA to the plate.
6. Using a small square tipped shovel and/or scoop, carefully remove all the HMA from inside of the cutter and place in a sample container.
7. Remove the sample cutter and the plate from the roadway. The hole made from the sampling must be filled with loose HMA.

Method 2 Obtaining a Sample on Asphalt Surface:

1. After the paving machine has passed the sampling point, immediately place the "cookie cutter" sampling device on the location to be sampled. Push the cutter down through the HMA until it is flat against the underlying asphalt mat.
2. Using a small square tipped shovel and/or scoop, carefully remove all the HMA from inside of the cutter and place in a sample container. The hole made from sampling must filled with loose HMA.

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Identification and Shipping

1. Identify sample containers as required by the agency.
2. Ship samples in containers that will prevent loss, contamination, or damage.

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Tips!

Check agency requirements for:

- Sample size needed
- Sampling device requirements
- Allowable sampling techniques

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REVIEW QUESTIONS

1. Bituminous paving mixture sample sizes are based on what?

2. What types of containers are used for asphalt samples?

3. Describe how samples are obtained from:

   - Conveyor belt
   - Plants with attached sampling devices
   - Truck transports
   - Roadway

PERFORMANCE EXAM CHECKLIST (ORAL)

SAMPLING BITUMINOUS PAVING MIXTURES
FOP FOR AASHTO T 168

Participant Name _____ Exam Date _____

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	**Trial 1**	**Trial 2**
1. How must a sample be obtained from a conveyor belt?		
a. Stop the belt and insert the template.	_____	_____
b. Remove all material from inside the template.	_____	_____
c. Take three increments.	_____	_____
2. At the hot plant how must a sample be obtained using a sampling device?		
a. Pass the sampling device through stream twice perpendicular to material.	_____	_____
b. The sampling device can not be over filled.	_____	_____
3. What must be done to sample from transport units?		
a. Divide the unit into four quadrants.	_____	_____
b. Obtain increments from each quadrant, 12 in below surface.	_____	_____
4. Describe how to take samples from the roadway using a plate.		
a. Place the plate well in front of the paver.	_____	_____
b. Pull the wire to locate the corner of the plate.	_____	_____
c. Place the cutter on the HMA above the plate and push it down to the plate.	_____	_____
d. Collect all the material inside the cutter.	_____	_____
5. What types of containers can be used?		
a. Card board boxes, stainless steel bowls, or other agency approved containers.	_____	_____
6. What dictates size of sample?		
a. Agency requirements.	_____	_____

Comments: First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

_____

Examiner Signature _____ WAQTC #:_____

REDUCING SAMPLES OF HOT MIX ASPHALT TO TESTING SIZE FOP FOR AASHTO T 328

Significance

02 Samples of bituminous paving mixes taken in accordance with the FOP for AASHTO T 168, or as required by individual approved test methods, are composites and are typically large in size. Materials sampled in the field need to be reduced to appropriate sizes for testing. It is extremely important that the procedure used to reduce the field sample not modify the material properties.

Scope

03 This method covers three procedures for reducing samples of Hot Mixed Asphalt (HMA) to testing size. The reduced portion is to be representative of the original sample.

- Method A – Mechanical Splitter
- Method B – Quartering
- Method C – Riffle Splitter
- A combination of these methods may be used if approved by the agency.

Apparatus

General

04

Oven

- Thermostatically controlled oven capable of maintaining a temperature of at least 230°F or sufficient to heat the material to a pliable condition for splitting.
- Non-contact temperature measuring device.
- Agency-approved release agent free of solvent or petroleum-based material that could affect asphalt binder.
- Metal spatulas, trowels, straightedges, taping knives, for removing HMA samples from the quartering device, cleaning splitting surfaces, etc.
- Miscellaneous equipment including hot plate, non-asbestos heat-resistant gloves or mittens, pans, buckets, and cans.

Mechanical Splitter

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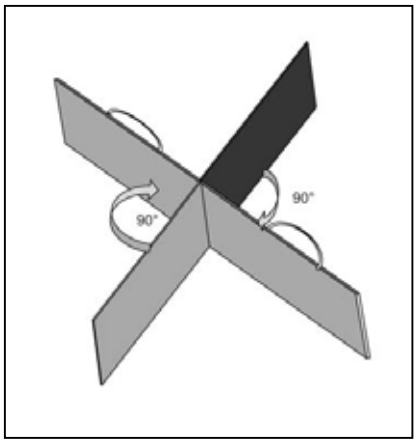
- **Mechanical Splitter** having four equal width chutes discharging into four appropriately sized sample receptacles. Splitter to be equipped with a receiving hopper that will hold the sample until the release lever is activated.
- Four sample receptacles of sufficient capacity to accommodate the reduced portion of the HMA sample from the mechanical splitter.
- Refer to AASHTO T 328, Figures 1 through 3, for configuration and required dimensions of the mechanical splitter.



Quartering Template

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- **Quartering Template** formed in the shape of a cross having equal length sides at right angles to each other. Manufactured of metal that will withstand heat and use without deforming. The sides of the quartering template should be sized such that the length exceeds the diameter of the flattened cone of HMA by an amount allowing complete separation of the quartered sample. (AASHTO T 328 requires length of the sides to be 1.1 times the diameter of the flattened cone of HMA). Height of the sides must exceed the thickness of the flattened cone of HMA.
- Non-stick mixing surface that is hard, heat-resistant, clean, level, and large enough to permit HMA samples to be mixed without contamination or loss of material.

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- Square-tipped, flat-bottom scoop, shovel or trowel for mixing HMA prior to quartering.

Riffle Splitter

10 • **Riffle Splitter** having a minimum of eight equal width chutes discharging alternately to each side. Minimum chute width must be at least 50% larger than the largest particle size.

11 • Hopper or straight edged pan having width equal or slightly smaller than the assembly of chutes in the riffle splitter to permit uniform discharge of the HMA through the chutes without segregation or loss of material.

• Sample receptacles of sufficient width and capacity to receive the reduced portions of HMA from the riffle splitter without loss of material.

Sampling

12 Obtain samples according to the FOP for AASHTO T 168.

Sample Preparation

13 The sample must be warm enough to separate. If not, warm in an oven until it is sufficiently pliable to mix and separate easily. Do not exceed either the temperature or time limits specified in the test method(s) to be performed.

Selection of Procedure (Method)

14 Select procedure for sample reduction according to agency requirements.

Method A or C is preferred due to the speed with which samples are reduced to testing size. With Method B (Quartering), the repeated mixing and quartering process allows samples to cool rapidly.

The size of the original sample may determine which method is used.

Procedure

Method A – Mechanical Splitter

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1. After inspecting the apparatus for cleanliness, apply a light coating of approved release agent to all splitter surfaces that will contact HMA.
2. Inspect the hopper gates to be sure they are secured in the closed position.
3. Position the four sample receptacles to receive reduced HMA portions without loss of material.

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4. Remove the sample from the agency-approved container(s) and place in the mechanical splitter hopper. Avoid segregation, loss of HMA or the accidental addition of foreign material.
5. Release the handle allowing the HMA to drop through the divider chutes and discharge into the four receptacles.

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6. Inspect splitter surfaces for aggregations of HMA or mastic. If present, clean these surfaces such that the adherent material discharges into the appropriate receptacles.
7. Close and secure the hopper gates.

   Note: *It is possible at this point that material contained in opposite receptacles would equal the required sample size. If this is the case, combine the material from opposite receptacles for the sample.*

Reduced sample

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8. Further reduce the remaining HMA as needed. Reintroduce material contained in selected receptacles from opposite corners.
9. Repeat the splitting process until an appropriate sample size is obtained for the first test.

Note 1 - Unless the sample size is grossly in excess of the minimum or exceeds the maximum test size use the sample as reduced for the test.

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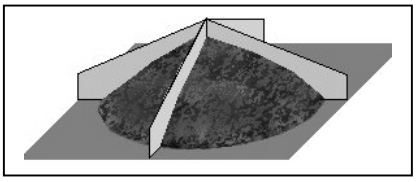
10. Continue the process with the unused portion of the HMA until samples have been obtained for all required tests.
11. Retain and properly identify the remaining unused portion of the HMA sample for further testing if required by the agency.

Method B – Quartering

1. Heat quartering tools to approximately 230ºF (Metal quartering template, scoop or trowel).
2. If needed, apply a light coating of release agent to quartering template.
3. Remove the sample from its container and place in a conical pile on a clean, hard, non-stick surface large enough to permit mixing without contamination or loss of material.
4. Mix thoroughly a minimum of three times using the heated scoop or trowel to turn the sample. Be certain to insert the scoop to the center of the pile to ensure that the entire mass of HMA is being mixed. With the last turning, form again into a conical pile.
5. Flatten the conical pile to a uniform diameter and thickness where the diameter is four to eight times the thickness.
6. Divide the flattened cone into four equal quarters using the quartering template. Press the template through the thickness of the flattened cone assuring complete separation.



Quartering Template (In Place)

7. Leaving the quartering template in place, remove two diagonally opposite quarters and return them to the sample container. Be certain to remove all aggregations of HMA and mastic.
8. Remove the quartering template and combine the remaining quarters, again forming a conical pile.
9. Repeat steps 4 through 8 until a sample of the required size has been obtained. The final sample must consist of the two remaining diagonally opposite quarters.
10. Continue the process with the unused portion of the HMA until samples have been obtained for all required tests.
11. Retain and properly identify the remaining unused portion of the HMA sample for further testing if required by the agency.

Note 1 - Unless the sample size is grossly in excess of the minimum or exceeds the maximum test size use the sample as reduced for the test.

Method C – Riffle Splitter

32 1. Heat splitting tools not to exceed 230ºF. Inspect the riffle splitter for cleanliness and that receptacles are in place to receive the reduced portions of the HMA.

2. Apply a light coating of approved release agent to splitting surfaces (hopper or straight edged pan, chutes, receptacles).

3. Carefully empty the HMA from the sample container into the hopper or straight edged pan without loss of material. Uniformly distribute from side to side of the hopper or pan.

33 4. Discharge the HMA into the splitter at a uniform rate, allowing the HMA to flow freely through the chutes.

5. Inspect splitter surfaces for aggregations of HMA or mastic. If present, clean these surfaces such that the adherent material discharges into the appropriate receptacles.

6. Replace the two receptacles containing the split portions of HMA with two empty ones.

34 7. Using one of the two receptacles containing HMA from the first split, repeat steps 4 and 5 until the HMA contained in one of the two receptacles is the appropriate size for the required test.

8. After each split, remember to inspect splitter hopper and chute surfaces for aggregations of HMA or mastic. If present, clean these surfaces such that the adherent material discharges into the appropriate receptacles.

35 9. Repeat the splitting process with the unused portion of the HMA until samples have been obtained for all required tests.

10. Retain and properly identify the remaining unused portion of the HMA sample for further testing if required by the agency.

Note 1 - Unless the sample size is grossly in excess of the minimum or exceeds the maximum test size use the sample as reduced for the test.

Tips!

- Remember, the reduced sample must be representative of the whole. 36
- Proceed quickly so that splitting is done when the material is hot.
- Check agency requirements about what splitting device(s) or method(s) may be used.
- Method A or C is preferred.
- With Method A, further reduction requires using HMA from diagonally opposite receptacles. 37
- With Methods A or C, inspect splitter surfaces for build-up of HMA aggregations or mastic. Ensure they are cleaned such that the material falls into the appropriate receptacles before continuing with another split.
- With Method B remember that the final sample consists of the two remaining diagonally opposite quarters.

Sample Identification

1. Identify the sample as required by the agency.
2. Samples shall be submitted in agency-approved containers and secured to prevent contamination and loss of material.

REVIEW QUESTIONS

1. What precautions must be taken with the tools used in splitting?

2. What type(s) of equipment can be used for HMA sample reduction?

3. Describe how the “Mechanical Splitter” is prepared for use.

4. Describe the requirements for the Quartering Template.

5. How are methods A, B, & C different?

6. Can methods A, B, and C be used in combination?

7. Describe the Riffle Splitter (configuration, chute size, number of chutes, etc.)

8. Which sample reduction method(s) is preferred? Why?

9. Describe the final sample as reduced by the Quartering method.

10. Describe what the approved release agent cannot contain.

PERFORMANCE EXAM CHECKLIST

REDUCING SAMPLES OF HOT MIX ASPHALT TO TESTING SIZE FOP FOR AASHTO T 328

Participant Name _____ Exam Date _____

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	**Trial 1**	**Trial 2**
1. Sample obtained by FOP for AASHTO T 168?	_____	_____
2. Sample warmed if not sufficiently pliable to separate easily?	_____	___
3. Tools such as trowels, spatulas, taping knives, etc. heated?	_____	_____
Method A (Mechanical Splitter)		
4. Splitter checked for cleanliness and receptacles in place?	_____	_____
5. Splitter surfaces that will contact HMA coated with approved release agent?	_____	_____
7. 6. Sample introduced into hopper without segregation or loss of material?	_____	_____
7. Hopper opened. HMA readily and uniformly flows into receptacles?	_____	_____
8. Splitter surfaces inspected, cleaned if needed. Aggregations of mastic or HMA scraped so they fall into appropriate receptacles?	_____	_____
9. Receptacles from opposite corners combined and steps 6 through 8 repeated until sample of required size obtained?	_____	_____
10. Unused portions of HMA then used for continuing the splitting process until samples for all required tests are obtained?	_____	_____
11. Remaining HMA stored in suitable container, properly labeled?	_____	_____
Method B (Quartering)		
12. Tools preheated to approximately 230ºF?	_____	_____
13. Sample placed on hard, non-stick, heat-resistant splitting surface?	_____	_____
14. Sample mixed by turning over a minimum 3 times?	_____	_____
15. Conical pile formed and then flattened?	_____	_____
16. Diameter equal to about 4 to 8 times thickness?	_____	_____
17. Divided into 4 equal portions with heated metal quartering template?	_____	_____
18. Leaving template in place, two diagonally opposite quarters removed and returned to sample container?	_____	_____

OVER

19. Cleared spaces scraped clean? _____ _____
20. Remaining two quarters combined and steps 14 through 19 repeated until sample of required size is obtained? _____ _____
21. Final sample size consists of two diagonally opposite quarters? _____ _____
22. Process continued with unused portions of HMA until samples for all required tests obtained? _____ _____
23. Remaining unused HMA stored in suitable container, properly labeled? _____ _____

Method C (Riffle Splitter)

24. Splitting apparatus and tools preheated to approximately 230ºF? _____ _____
25. Splitter and pans inspected for cleanliness and approved release agent applied? _____ _____
26. Material removed from sample container and placed in hopper or straight edged pan uniformly distributed from side to side? _____ _____
27. Material discharged across chute assembly at controlled rate allowing free flow of HMA through chutes into receptacles? _____ _____
28. Chutes and hopper inspected for cleanliness. Aggregations of HMA or mastic scraped so they fall into appropriate receptacles? _____ _____
29. Receptacles removed and replaced with clean, empty ones? _____ _____
30. Using one receptacle containing HMA from the first split, steps 27 through 28 repeated until sample of the required size is obtained? _____ _____
31. Process continued with unused portions of HMA until samples for all required tests obtained? _____ _____
32. Remaining unused HMA stored in suitable container, properly labeled? _____ _____

Comments: First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

Examiner Signature _____ WAQTC #:_____

SAMPLING BITUMINOUS MATERIALS
FOP FOR AASHTO T 40

Significance

01

The quality of bituminous materials has a tremendous impact on a roadway project. The grade of binder selected is based on a number of

02

factors, including local temperature extremes and characteristics of expected traffic. Using a grade of binder material other than that specified will have serious impacts on roadway performance and durability.

Scope

The procedure covers obtaining samples of liquid bituminous materials in accordance with AASHTO T 40. Sampling of solid and semi-solid bituminous materials – included in AASHTO T 40 – is not covered here.

Agencies may be more specific on exactly who samples, where to sample, and what type of sampling device to use.

Procedure

1. Coordinate sampling with contractor or

03

supplier.

2. Use appropriate safety equipment and precautions for hot liquids.
3. Allow a minimum of 1 gal to flow before obtaining a sample(s).
4. Obtain samples of:
   - Asphalt binder from Hot Mix Asphalt (HMA) Plant: from the line between the storage tank and the mixing plant while the plant is in operation, or from the delivery truck.
   - Cutback and Emulsified asphalt from distributor spray bar or application device or from the delivery truck before it is pumped into the distributor: Sample emulsified asphalt at delivery or prior to dilution.

04

05

Sampling liquid binder

Containers

Sample containers must be new, and the inside may not be washed or rinsed. The outside may be wiped with a clean, dry cloth.

06 All samples shall be put in 1 qt containers and properly identified on the outside of the container with contract number, date sampled, data sheet number, brand and grade of material, and sample number. Include lot and sublot numbers when appropriate.

07
- Emulsified asphalt: Use wide-mouth plastic jars with screw caps. Protect the samples from freezing since water is a part of the emulsion. The sample container should be completely filled to minimize a skin formation on the sample.

- Asphalt binder and Cutbacks: Use metal cans.

Note: The filled sample container shall not be submerged in solvent, nor shall it be wiped with a solvent saturated cloth. If cleaning is necessary, use a clean dry cloth.

Tips!

08
- Remember to identify sample on outside of container.

REVIEW QUESTIONS

1. Describe how liquid bituminous material is obtained at an HMA plant.

2. Describe how liquid bituminous material is obtained from a spray distributor.

3. Describe the containers used for sampling.

PERFORMANCE EXAM CHECKLIST (ORAL)

SAMPLING BITUMINOUS MATERIALS
FOP FOR AASHTO T 40

Participant Name _____ Exam Date _____

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	**Trial 1**	**Trial 2**
1. Describe the container that is used to sample bituminous liquids.		
a. New metal can, 1 qt in size.	_____	_____
2. Describe the container that is used to sample emulsified liquids.		
a. New wide mouth plastic jar, 1 qt in size.	_____	_____
3. How much material must be wasted before a sample can be obtained?		
a. A minimum of 1 gal.	_____	_____
4. At a hot plant where must a sample be taken?		
a. In the line between storage tank and mixing plant or from delivery vehicle.	_____	_____
5. Where is an emulsified sample taken?		
a. Spray bar or application device, if not diluted.	_____	_____
b. From delivery vehicle or prior to dilution, if diluted.	_____	_____

Comments: First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

_____

_____

_____

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_____

_____

_____

_____

Examiner Signature _____WAQTC #:_____

IN-PLACE DENSITY AND MOISTURE CONTENT OF SOIL AND SOIL-AGGREGATE BY NUCLEAR METHODS (SHALLOW DEPTH)

FOP FOR AASHTO T 310

01

02

03

04

Checking deflection

05

06

Caution!

07

08

Significance

The final in-place density of roadway embankment and base is critical to the quality and longevity of a highway project. Low-density material will lead to excessive deflection under load and/or permanent deformation.

This procedure provides a rapid, nondestructive technique for determining the in-place wet density and moisture content of soil, aggregate, and soil-aggregate mixes. The non-destructive nature of the test allows repetitive measurements to be made at a single test location between roller passes. The procedure is normally suitable from test depths of 2 in. to 12 in.

Scope

This procedure covers the determination of density, moisture content, and relative compaction of soil, aggregate, and soil-aggregate mixes in accordance with AASHTO T 310. This field operating procedure is derived from AASHTO T 310. The nuclear moisture-density gauge is used in the direct transmission mode.

Apparatus

- Nuclear density gauge with the factory matched standard reference block.
- Drive pin, guide / scraper plate, and hammer for testing in direct transmission mode.
- Transport case for properly shipping and housing the gauge and tools.
- Instruction manual for the specific make and model of gauge.
- Radioactive materials information and calibration packet containing:
  - Daily Standard Count Log
  - Factory and Laboratory Calibration Data Sheet
  - Leak Test Certificate
  - Shippers Declaration for Dangerous Goods

Nuclear gauge

09

- Procedure Memo for Storing, Transporting and Handling Nuclear Testing Equipment.
- Other radioactive materials documentation as required by local regulatory requirements.

10

- Sealable containers and utensils for moisture content determinations.

Radiation Safety

11

- This method does not purport to address all of the safety problems associated with its use. The gauge utilizes radioactive materials that may be hazardous to the health of the user unless proper precautions are taken. Users of this gauge must become familiar with the applicable safety procedures and governmental regulations. All operators will be trained in radiation safety prior to operating nuclear density gauges. Some agencies require the use of personal monitoring devices such as a thermo luminescent dosimeter or film badge. Effective instructions together with routine safety procedures such as source leak tests, recording and evaluation of personal monitoring device data, etc., are a recommended part of the operation and storage of this gauge.

Calibration

12

Calibrate the nuclear gauge as required by the agency. This calibration may be performed by the agency using manufacturer's recommended procedures or by other facilities approved by the agency. Verify or re-establish calibration curves, tables, or equivalent coefficients every 12 months.

Standardization

13

1. Turn the gauge on and allow it to stabilize (approximately 10 to 20 minutes) prior to standardization. Leave the power on during the day's testing.
2. Standardize the nuclear gauge at the construction site at the start of each day's work and as often as deemed necessary by the operator or agency. Daily variations in standard count shall not exceed the daily variations

established by the manufacturer of the gauge.

If the daily variations are exceeded after repeating the standardization procedure, the gauge should be repaired and or recalibrated.

3. Record the standard count for both density and moisture in the Daily Standard Count Log. The exact procedure for standard count is listed in the manufacturer's Operators Manual.

Note 1: New standard counts may be necessary more than once a day. See agency requirements.

Overview

14

There are two methods for determining in-place determination of soil / soil aggregate

- Method A: Single Direction
- Method B: Two Directions

Procedure

15

1. Select a test location(s) randomly and in accordance with agency requirements. Test sites should be relatively smooth and flat and meet the following conditions:
   a) At least 30 ft away from other sources of radioactivity
   b) At least 10 ft away from large objects
   c) The test site should be at least 6 in. away from any vertical projection, unless the gauge is corrected for trench wall effect.
2. Remove all loose and disturbed material, and remove additional material as necessary to expose the top of the material to be tested.

16

3. Prepare a flat area sufficient in size to accommodate the gauge. Plane the area to a smooth condition so as to obtain maximum contact between gauge and the material being tested. For Method B, the flat area must be sufficient to permit rotating the gauge 90 or 180 degrees about the source rod.

17

4. Fill in surface voids beneath the gauge with native fines passing the No. 4 sieve or finer. Smooth the surface with the guide plate or other suitable tool. The depth of the native fines filler should not exceed approximately 1/8 in.

18

5. Make a hole perpendicular to the prepared surface using the guide plate and drive pin. The hole shall be at least 2 in. deeper than the desired probe depth, and shall be aligned such that insertion of the probe will not cause the gauge to tilt from the plane of the prepared area. Remove the drive pin by pulling straight up and twisting the extraction tool.

19

6. Place the gauge on the prepared surface so the source rod can enter the hole without disturbing loose material.

20

7. Insert the probe in the hole and lower the source rod to the desired test depth using the handle and trigger mechanism.
8. Seat the gauge firmly by partially rotating it back and forth about the source rod. Ensure the gauge is seated flush against the surface by pressing down on the gauge corners, and making sure that the gauge does not rock.
9. Pull gently on the gauge to bring the side of the source rod nearest to the scaler/detector firmly against the side of the hole.

10. Perform one of the following as required by agency:

    a. **Method A Single Direction**: Take a test consisting of the average of two, one minute readings, and record both density and moisture data. The two wet density readings should be within 2.0 lb/ft^3 of each other. The average of the two wet densities and moisture contents will be used to compute dry density.

    b. **Method B Two Direction:** Take a one-minute reading and record both density and moisture data. Rotate the gauge 90 degrees or 180, pivoting it around the source rod. Reseat the gauge by pulling gently on the gauge to bring the side of the source rod nearest to the scaler / detector firmly against the side of the hole and take one-minute reading. (In trench locations, rotate the gauge 180 degrees for the second test.) Some agencies require multiple one-minute readings in both directions. Analyze the density and moisture data. A valid test consists of wet density readings in both gauge positions that are within 3.0 lb/ft^3. If the tests do not agree within this limit, move to a new location. The average of the wet density and moisture contents will be used to compute dry density.

11. If required by the agency, obtain a representative sample of the material, 9 lb minimum, from directly beneath the gauge full depth of material tested. This sample will be used to verify moisture content and / or identify the correct density standard. Immediately seal the material to prevent loss of moisture.

Sampling Density site

The material tested by direct transmission can be approximated by a cylinder of soil approximately 12” in diameter directly beneath the centerline of the radioactive source and detector. The height of the cylinder will be approximately the depth of measurement. When organic material or large aggregate is removed during this operation, disregard the test information and move to a new test site.

12. To verify the moisture content from the nuclear gauge, determine the moisture content with a representative portion of the material using the FOP for AASHTO T 255/ T 265 or FOP for AASHTO T 217. If the moisture content from the nuclear gauge is within ±1% the nuclear gauge readings can be accepted. Retain the remainder of the sample at its original moisture content for a one-point compaction test under the FOP for AASHTO T 272, or for gradation, if required.

Note2: Example; A gauge reading of 16.8% moisture and oven dry or 17.7% are within the 1% requirements. Moisture correlation curves will be developed according to agency guidelines. These curves should be reviewed and possibly redeveloped every 90 days because of moisture source decay.

13. Determine the dry density by one of the following.

    a. From nuclear gauge readings, compute by subtracting the mass (weight) of the water (lb/ft^3) from the wet density (lb/ft^3) or compute using the % moisture by dividing wet density from the nuclear gauge by 1 + moisture content expressed as a decimal.

    b. When verification is required and the nuclear gauge readings cannot be accepted, the moisture content is determined by the FOP for AASHTO T 255/T 265 or FOP for AASHTO T 217, compute dry density by dividing wet density from the nuclear gauge by 1 + moisture content expressed as a decimal.

Percent Compaction

- Percent compaction is determined by comparing the in-place dry density as determined by this procedure to the appropriate agency density standard. For soil or soil-aggregate mixes, these are moisture-density curves developed using the FOP for AASHTO T 99/ T 180. When using curves developed by the FOP for AASHTO T 99 /T 180, it may be necessary to use the FOP for AASHTO T 224 and FOP for AASHTO T

272 to determine maximum density and moisture determinations.

For coarse granular materials, the density standard may be density-gradation curves developed using a vibratory method such as AKDOT&PF's ATM 212, ITD's T 74, WSDOT's TM 606, or WFLHD's Humphrys.

See appropriate agency policies for use of density standards.

Calculation

Wet Density readings from gauge: 121.6 lb/ft^3 30

123.4 lb/ft^3

Ave: 122.5 lb/ft^3

Moisture readings from gauge: 14.2% & 15.4% = Ave 14.8%

Moisture content from the FOP's for AASHTO T 255 / T 265 or T 217: 15.9%

Moisture content is greater than 1% different so the gauge moisture cannot be used.

Calculate the dry density as follows:

$$\rho_d = \left(\frac{\rho_w}{w+100} \right) \times 100 \quad \text{or} \quad \rho_d = \left(\frac{\rho_w}{\frac{w}{100}+1} \right) \qquad 31$$

where

ρ_d = Dry density, kg/m^3 (lb/ft^3)

ρ_w = Wet density, kg/m^3 (lb/ft^3)

w = Moisture content from the FOPs for AASHTO T 255 / T 265 or T 217, as a percentage

$$\rho_d = \left(\frac{122.5 \text{lb/ft}^3}{15.9+100} \right) \times 100 \qquad \rho_d = \left(\frac{122.5 \text{lb/ft}^3}{\frac{15.9}{100}+1} \right) \qquad 32$$

Corrected for moisture Dry Density: 105.7 lb/ft^3

Percent Compaction:

Calculate the percent compaction as follows:

$$\frac{\text{Gauge Dry Density}}{\text{Agency Density Standard}} \times 100 = \text{\% Compaction}$$

where

Gauge Dry Density = 105.7 lb/ft^3

Agency Density Standard = 116.1 lb/ft^3

$$\frac{105.7\ \text{lb/ft}^3}{116.1\ \text{lb/ft}^3} \times 100 = 91.0\%\ \text{Compaction}$$

33

Report

Results shall be reported on standard forms approved by the agency. Include the following information:

- Location of test, elevation of surface, and thickness of layer tested
- Visual description of material tested
- Make, model and serial number of the nuclear moisture-density gauge
- Wet density to 0.1 lb/ft^3
- Moisture content as a percent, by mass, of dry soil mass to 0.1 percent
- Dry density to 0.1 lb/ft^3
- Standard density to 0.1 lb/ft^3
- Percent compaction
- Name and signature of operator

Tips!

- Check to make sure that: 34
  - base of gauge is clean prior to testing.
  - shutter block and assembly are free of debris and operating correctly.
  - source rod tip does not have a build up of material on end.
  - gauge is reading the proper position of the source rod when it is indexed, and that it has been seated correctly.
  - the hole into which the source is lowered is at least 2 in. deeper than the 35 indexed position of the source rod.
  - surface is flat and the gauge does not rock.
  - surface has been properly prepared using filler material.
- Make sure battery is charged before starting work

REVIEW QUESTIONS

1. Describe the calibration and standardization process.

2. What precautions must be taken in selecting a test location?

3. Describe the procedure leading up to the taking of test measurements.

4. What is the difference between Method A and Method B?

5. What is the purpose of determining moisture content following the FOP for AASHTO T 255/T 265 or the FOP for AASHTO T 217?

PERFORMANCE EXAM CHECKLIST

IN-PLACE DENSITY AND MOISTURE CONTENT OF SOIL AND SOIL-AGGREGATE BY NUCLEAR METHODS (SHALLOW DEPTH) FOP FOR AASHTO T 310

Participant Name _____ Exam Date _____

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	Trial 1	Trial 2
1. Gauge turned on 10 to 20 minutes before use?	_____	_____
2. Calibration verified?	_____	_____
3. Standard count taken and recorded in accordance with manufacturer's instructions?	_____	_____
4. Test location selected appropriately 30 ft from other radioactive sources, 10 ft from large objects, 6 in away from vertical projections?	_____	_____
5. Loose, disturbed material removed?	_____	_____
6. Flat, smooth area prepared?	_____	_____
7. Surface voids filled with native fines to 1/8 in maximum thickness?	_____	_____
8. Hole driven 2 in deeper than probe depth?	_____	_____
9. Gauge placed, probe placed, and source rod lowered without disturbing loose material?	_____	_____
10. Method A:		
a. Gauge firmly seated, and gently pulled so that the source rod is against the side of the hole toward the scaler / detectors?	_____	_____
b. Two, one-minute reading taken; wet density within 2.0 lb/ft^3?	_____	_____
c. Density and moisture data averaged?	_____	_____
11. Method B:		
a. Gauge firmly seated, and gently pulled so that the source rod is against the side of the hole toward the scaler / detectors?	_____	_____
b. A minimum of a one-minute reading taken; density and moisture data recorded?	_____	_____
c. Gauge turned 90° or 180° (180° in trench)?	_____	_____

OVER

Procedure Element	**Trial 1**	**Trial 2**
d. Gauge firmly seated, and gently pulled so that the source rod is against the side of the hole toward the scaler / detectors?	_____	_____
e. A minimum of a one-minute reading taken; density and moisture data recorded?	_____	_____
f. Wet densities within 3.0 lb/ft^3?	_____	_____
g. Density and moisture data averaged?	_____	_____
12. Representative sample (9 lbs) obtained from test location?	_____	_____
13. Sample sealed immediately to prevent moisture loss?	_____	_____
14. Moisture content determined using FOP's for AASHTO T 255/T 265 or AASHTO T 217?	_____	_____
15. Dry Density calculated using proper moisture content?	_____	_____
16. Percent compacted calculated correctly?	_____	_____

Comments: First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

Examiner Signature _____WAQTC #:_____

IN-PLACE DENSITY OF BITUMINOUS MIXES USING THE NUCLEAR MOISTURE-DENSITY GAUGE

FOP FOR WAQTC TM 8

01

02

03

Caution!

04

05

Significance

The final in-place density of roadway pavement is critical to the quality and longevity of a highway project. Low-density material will lead to excessive deflection under load and/or permanent deformation.

This procedure provides a rapid, nondestructive technique for determining the in-place density of compacted bituminous mixes. It can be used to establish the proper rolling effort and pattern to achieve the required density. The non-destructive nature of the test allows repetitive measurements to be made at a single test location between roller passes.

Scope

This test method describes a test procedure for determining the density of bituminous mixes by means of a nuclear gauge employing either direct transmission or backscatter methods. Correlation with densities determined under the FOP for AASHTO T 166 is required by some agencies.

Apparatus

- Nuclear density gauge with the factory matched standard reference block.
- Drive pin, guide / scraper plate, and hammer for testing in direct transmission mode.
- Transport case for properly shipping and housing the gauge and tools.
- Instruction manual for the specific make and model of gauge.

Filler on pavement

- Radioactive materials information and calibration packet containing:
  - Daily Standard Count Log
  - Factory and Laboratory Calibration Data Sheet
  - Leak Test Certificate
  - Shippers Declaration for Dangerous Goods
  - Procedure Memo for Storing, Transporting and Handling Nuclear Testing Equipment
  - Other radioactive materials documentation as required by local regulatory requirements.

Material

- Filler material: Fine graded sand from the source used to produce the asphalt pavement or other agency approved materials.

Radiation Safety

This method does not purport to address all of the safety problems associated with its use. The gauge utilizes radioactive materials that may be hazardous to the health of the user unless proper precautions are taken. Users of this gauge must become familiar with the applicable safety procedures and governmental regulations. All operators will be trained in radiation safety prior to operating nuclear density gauges. Some agencies require the use of personal monitoring devices such as a thermo luminescent dosimeter or film badge. Effective instructions together with routine safety procedures such as source leak tests, recording and evaluation of personal monitoring device data, etc., are a recommended part of the operation and storage of this gauge.

11

Calibration

Calibrate the nuclear gauge as required by the agency. This calibration may be performed by the agency using manufacturer's recommended procedures or by other facilities approved by the agency. Verify or re-establish calibration curves, tables, or equivalent coefficients every 12 months.

12

Standardization

1. Turn the gauge on and allow it to stabilize (approximately 10 to 20 minutes) prior to standardization. Leave the power on during the day's testing.
2. Standardize the nuclear gauge at the construction site at the start of each day's work and as often as deemed necessary by the operator or agency. Daily variations in standard count shall not exceed the daily variations established by the manufacturer of the gauge. If the daily variations are exceeded after repeating the standardization procedure, the gauge should be repaired and or recalibrated.
3. Record the standard count for both density and moisture in the Daily Standard Count Log. The exact procedure for standard count is listed in the manufacturer's Operators Manual.

13

Note 1: New standard counts may be necessary more than once a day. See agency requirements.

Test Site Location

14

1. Select a test location(s) randomly and in accordance with agency requirements. Test sites should be relatively smooth and flat and meet the following conditions:
   a. At least 30 ft away from other sources of radioactivity
   b. At least 10 ft away from large objects
   c. If the gauge will be closer than 24 in. to any vertical mass, or less than 12 in. from a vertical pavement edge,

use the gauge manufacturer's correction procedure.

Overview

15

There are two methods for determining in-place density of HMA. See agency requirements method selection.

- Direct Transmission
- Backscatter

Procedure

Direct Transmission

16

1. Maximum contact between the base of the gauge and the surface of the material under test is critical.
2. Use the guide and scraper plate as a template and drill a hole to a depth of at least 1/4 in. deeper than the measurement depth required for the gauge.
3. Place the gauge on the prepared surface so the source rod can enter the hole. Insert the probe in the hole and lower the source rod to the desired test depth using the handle and trigger mechanism. Position the gauge with the long axis of the gauge parallel to the direction of paving. Pull the gauge so that the probe is firmly against the side of the hole.

17

4. Take two one-minute tests and record the wet density (WD) readings. If the two density readings are not within 3 lbs/ft^3 rotate the gauge 180 degrees and repeat the test in the same hole until they do agree.

Backscatter

18

1. Maintain maximum contact between the base of the gauge and the surface of the material under test. Use filler material to fill surface voids. Spread a small amount of filler material over the test site surface and distribute it evenly. Strike off the surface with a straight edge to remove excess material.

19

Nuclear gauge

2. Place the gauge on the test site. Using a crayon, (not spray paint) mark the outline or footprint of the gauge. Extend the probe to the backscatter position.
3. Take a one-minute test and record the wet density reading.
4. Rotate the gauge 90 degrees about the probe. Mark the outline or footprint of the gauge.

20

5. Take another one-minute test and record the wet density reading.
6. If the difference between the two one minute tests is greater than 2.5 lb/ft^3, retest in both directions.

21

Calculation of Results

The density reported for each test site shall be the average of the two individual one-minute wet density readings.

Percent compaction is determined by comparing the in-place wet density as determined by this method to the appropriate agency density standard. See appropriate agency policy for use of density standards.

22

Example:

Reading #1: 141.5 lb/ft^3

Reading #2 (90º): 140.1 lb/ft^3

Are the two readings within tolerance? (YES)

Reading Average: 140.8 lb/ft^3

Core correction: +2.1 lb/ft^3

Corrected Reading: 142.9 lb/ft^3

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Determining Percent Compaction

G_{mm} and Maximum Density from the FOP for AASHTO T 209:

G_{mm} = 2.466

153.5 lb/ft^3 (2.466 x 62.245)

$$\frac{\text{Corrected Reading}}{\text{Maximum Density}} \times 100 = \%\ \text{compaction}$$

$$\frac{142.9}{153.5} \times 100 = 93.1\%$$

Correlation with Cores

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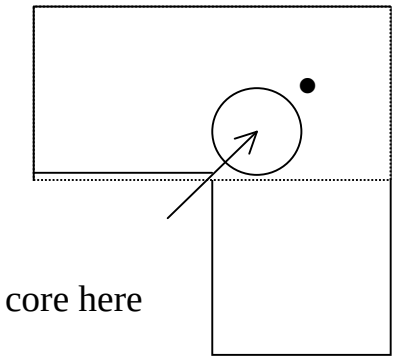
Note 2: When density correlation with test method AASHTO T 166 is required, correlation of the nuclear gauge with pavement cores shall be made on the first day's paving (within 24 hours) or from a test strip constructed prior to the start of paving. Cores must be taken before traffic is allowed on the pavement.

1. Determine the number of cores required for correlation from the agency's specifications. Cores shall be located on the first day's paving or on the test strip. Locate the test sites in accordance with the agency's specifications. Follow the "Procedure" section above to establish test sites and obtain densities using the nuclear gauge.

25

2. Obtain a pavement core from each of the test sites. The core should be taken from the center of the nuclear gauge footprint. If direct transmission was used, locate the core at least 1 in. away from the edge of the drive pin-hole.



Core location inside gauge footprint

3. Determine the density of the cores by AASHTO T 166, Bulk Specific Gravity of Compacted HMA Using Saturated Surface-Dry Specimens.

4. Calculate a correlation factor for the nuclear gauge reading as follows.

   a. Calculate the difference between the core density and nuclear gauge density at each test site to the nearest 0.1 lb/ft^3. Calculate the average difference and standard deviation of the differences for the entire data set to the nearest 0.1 lb/ft^3.

   b. If the standard deviation of the differences is equal to or less than 2.5 lb/ft^3, the correlation factor applied to the nuclear density gauge reading shall be the average difference calculated above in 4.a.

   c. If the standard deviation of the differences is greater than 2.5 lb/ft^3, the test site with the greatest variation from the average difference shall be eliminated from the data set and the data set properties and correlation factor recalculated following 4.a and 4.b.

   d. If the standard deviation of the modified data set still exceeds the maximum specified in 4.b, additional test sites will be eliminated from the data set and the data set properties and correlation factor recalculated following 4.a and 4.b. If the data set consists of less than five test sites, additional test sites shall be established.

Note 3: The exact method used in calculating the Nuclear Gauge Correlation Factor shall be defined by agency policy.

30

Note 4: The above correlation procedure must be repeated if there is a new job mix formula. Adjustments to the job mix formula beyond tolerances established in the contract documents will constitute a new job mix formula. A correlation factor established using this procedure is only valid for the particular gauge and in the mode and at the probe depth used in the correlation procedure. If another gauge is brought onto the project, it shall be correlated using the same procedure. Multiple gauges may be correlated from the same series of cores if done at the same time.

Note 5: For the purpose of this procedure, a job mix formula is defined as the percent and grade of paving asphalt used with a specified gradation of aggregate from a designated aggregate source. A new job mix formula may be required whenever compaction of the wearing surface exceeds the agency's specified maximum density or minimum air voids.

Core Correlation Example:

Core results from T166:	Density results TM 8:	Difference:
144.9 lb/ft^3	142.1 lb/ft^3	2.8 lb/ft^3
142.8 lb/ft^3	140.9 lb/ft^3	1.9 lb/ft^3
143.1 lb/ft^3	140.7 lb/ft^3	2.4 lb/ft^3
140.7 lb/ft^3	138.9 lb/ft^3	1.8 lb/ft^3
145.1 lb/ft^3	143.6 lb/ft^3	1.5 lb/ft^3
144.2 lb/ft^3	142.4 lb/ft^3	1.8 lb/ft^3
143.8 lb/ft^3	141.3 lb/ft^3	2.5 lb/ft^3

31

Average Difference: 2.1 lb/ft^3

Standard Deviation: 0.43 lb/ft^3

32

Report

Results shall be reported on standard forms approved by the agency. Include the following information:

- Location of test and thickness of layer tested
- Mixture type
- Make, model and serial number of the nuclear moisture-density gauge
- Mode of measurement, depth, calculated wet density of each measurement and any adjustment data
- Standard density
- Percent compaction and/or percent air voids
- Name and signature of operator

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Tips!

- Check to make sure that base of gauge is clean prior to testing.
- Shutter block and assembly are free of debris and operating correctly.
- Gauge is reading the proper position of the source rod when it is indexed, and that it has been seated correctly.
- When direct transmission is used, hole into which the source is lowered is at least 1/4 in. deeper than the indexed position of the source rod.

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- Surface is flat and the gauge does not rock.
- Surface has been properly prepared using filler material.
- Do not leave the gauge on a hot surface for a long time.

REVIEW QUESTIONS

1. Describe the calibration and standardization process.

2. What precautions must be taken in selecting a test location?

3. How do you determine percent compaction?

4. Describe the procedure for correlating results with pavement cores.

PERFORMANCE EXAM CHECKLIST

IN-PLACE DENSITY OF HOT MIX ASPHALT USING THE NUCLEAR MOISTURE-DENSITY GAUGE
FOP FOR WAQTC TM 8

Participant Name _____ Exam Date _____

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	**Trial 1**	**Trial 2**
1. Gauge turned on approximately 10 to 20 minutes before use?	_____	_____
2. Gauge calibrated and standard count recorded?	_____	_____
3. Test location selected appropriately 24 in. from vertical projections or 30 ft from any other radioactive sources)?	_____	_____
4. Direct Transmission :		
a. Hole made 1/4 in. deeper than intended probe depth?	_____	_____
b. Gauge placed, probe extended, gauge pulled toward scaler / detector?	_____	_____
c. Two one-minute counts taken:	_____	_____
d. Densities averaged?	_____	_____
e. If difference of the wet densities is greater than 3.0 lb/ft^3 gauge turned another 180° and retested?	_____	_____
5. Backscatter:		
a. Filler spread evenly over test site?	_____	_____
b. Excess filler material removed by striking off the surface?	_____	_____
c. Gauge placed on pavement surface and footprint of gauge marked?	_____	_____
d. Probe extended to backscatter position?	_____	_____
e. One-minute count taken; gauge rotated 90° reseated and another one-minute count taken?	_____	_____
f. Densities averaged?	_____	_____
g. If difference of the wet densities is greater than 2.5 lb/ft^3 retest conducted in both directions?	_____	_____

OVER

Procedure Element	**Trial 1**	**Trial 2**
6. Core correlation applied if required?	_____	_____
7. Percent compaction calculated correctly?	_____	_____

Comments: First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

_____

_____

Examiner Signature _____WAQTC #:_____

Section 984
SAMPLING METHODS

All samples are obtained in accordance with the applicable specifications. When random selection is required, select sample times or locations in accordance with Section 981 and ASTM D 3665 Standard Practice for Random Sampling of Construction Materials.

984.01 COARSE AND FINE AGGREGATE

Refer to AASHTO T 2: Standard Practice for Sampling Aggregates**.**

984.02 SAMPLING BITUMINOUS PAVING MIXTURES FROM BEHIND THE PAVER

984.02.01 Scope

This method covers sampling bituminous paving mixtures from the roadway behind the paver prior to compaction. Samples obtained by this procedure may be used for acceptance and quality control of materials whose point of acceptance is from the grade prior to compaction such as Hot Mix Asphalt.

984.02.02 Apparatus

1. Square mouth shovels
2. Trowel and scoops
3. A single metal plate with two feet minimum width and sufficient length to hold required sample size. The plate shall have a wire attached sufficient in length to extend beyond the edge of the mat.
4. Cookie cutter sampling device, square sampling template constructed from formed steel angle with two handles, device shall be sized to fit over metal plate without extending beyond it. (Optional)
5. Containers such as cardboard boxes, heat resistant buckets, and insulated containers.

984.02.03 Sample Size

Sample size depends on:

1. The test methods to be performed.
2. Number of labs performing testing
3. Project specification

984.02.04 Procedure

1. Coordinate sampling with paving crew and paving operator, ensuring safety.
2. Place the sampling plate longitudinally on the roadway ahead of the paver at a pre-determined random location.
3. Run the attached wire perpendicular to the direction of the paving operation, beyond the farthest auger extension and/or ski. Keep wire taut and on the ground to prevent snagging the auger extension and/or ski.
4. Allow the paving operation to run without interruption.
5. When the paver has passed over the plate, pull the wire to locate plate perimeter. (If the paver shifts the plate such that there is bituminous material under the plate, remove plate and start over.)

6. With plate still in place, remove full depth of bituminous material from the plate. Care should be taken to prevent sloughing of material. Optional use of cookie cutter: Place the sampling device over the plate, press device through material, and remove all material inside the sampling device.
7. Deposit bituminous material in suitable container; prevent contamination and segregation of material.

984.03 SAMPLING BITUMINOUS MATERIAL FROM A WINDROW

984.03.01 Scope

This method covers sampling bituminous material such as Hot-Mix Asphalt (HMA) from the windrow at the job-site. These samples are to be utilized for Hamburg Wheel Track Testing only. Materials Manual Part 8 Section 990.

984.03.02 Apparatus

1. Square mouth shovels
2. Containers such as cardboard boxes, heat resistant buckets, and insulated containers

984.03.03 Procedure

1. Choose a location along the windrow that appears uniform; avoid the beginning or the end of the windrow section.
2. Remove approximately 1 foot from the top of the windrow.
3. Bench out a section at an intermediate height on each side of the windrow.
4. Obtain one increment of the sample from the top of the windrow.
5. Obtain two more increments from the benched sections.
6. Deposit bituminous material in suitable container; prevent contamination and segregation of material.

984.04 SAMPLING BITUMINOUS MATERIAL FROM TRUCK TRANSPORTS

984.04.01 Scope

This method covers the UDOT modifications to AASHTO T 168: Sampling of Bituminous Paving Mixtures, when sampling bituminous mixtures whose point of acceptance is the plant from the transport unit such as Open-graded Surface Course (OGSC) and Bonded Wearing Course (BWC).

984.04.02 Apparatus

1. Square mouth shovel,
2. Square mouth scoop
3. Thermometer with a range of 100 to 400ºF,

4. Stainless steel bowl or pan of sufficient size for sample to be obtained

984.04.03 Procedure

1. Follow AASHTO T 168: Sampling of Bituminous Paving Mixtures Section 5.2.2 *"Sampling from Truck Transports"* with the following modifications: Sample may be obtained in a single increment.
2. Sample may be obtained at test sample size or larger and reduced to test sample size according to 8-985. (Refer to test method to be performed for sample size, i.e. T 308: Determining the Asphalt Binder Content of Hot-Mix Asphalt by the Ignition Method would require a 2000 g sample for ¾" Nominal Maximum Aggregate Size material).
3. Determine the temperature of the material in the same location sample was obtained.

984.04.04 Alternate Procedure

For sampling when the above procedure is deemed unsafe.

1. Fill a loader bucket from the hopper.
2. At a safe location, perform steps 2 and 3 above.
3. Remaining material in the loader bucket shall be loaded onto transport for delivery to job site. (Remainder of truck transport may be loaded from the hopper before, or after sample is obtained.)

984.05 SAMPLING BITUMINOUS MATERIAL AFTER COMPACTION (OBTAINING CORES)

984.05.01 Scope

This method covers the UDOT modifications to AASHTO T 168: Sampling of Bituminous Paving Mixtures, when obtaining test specimens (cores) of compacted bituminous material.

984.05.02 Apparatus

Core drill with a diamond cutting edge.

984.05.03 Procedure

Follow AASHTO T 168: Sampling of Bituminous Paving Mixtures Section 5.2.6 with the following modifications:

1. Sample may be obtained in a single increment.
2. Sample location is randomly selected in accordance with Section 981, ASTM D 3665 Standard Practice for Random Sampling of Construction Materials, and the Specifications under contract.
3. Party identified in the specification marks sample location. Sample shall be obtained within 6" of the marked sample location.
4. Samples obtained for in-place density and/or thickness shall be 4" diameter cylinders. Samples shall be obtained prior to traffic being allowed on the pavement. Care shall be taken not to damage specimen, damaged density specimens shall be discarded.

Replacement specimens shall be obtained within 1 foot of original location.

984.05.04 Transporting Cores

1. Transport cores in containers that prevent damage from jarring, i.e. dropping, rolling around, hitting together and/or impact with any object.
2. Prevent cores from freezing prior to testing.
3. Protect cores from excessive heat (130° F) prior to testing.
4. Damaged cores will not be used for acceptance tests.

Section 985
SAMPLE REDUCTION METHODS

985.01 Scope
This procedure covers the reduction of large samples of bituminous paving mixes, including hot mix asphalt (HMA), stone matrix asphalt (SMA) and cold mix asphalt field samples to the appropriate size for testing. These techniques are intended to minimize variations in measured characteristics between the test samples and the larger sample.

985.02 Procedure
Utilize AASHTO T 248; Reducing Samples of Aggregate to Testing Size with the following modifications:

Method A- Mechanical Splitter
Method A is the preferred method of reduction for dense-mix HMA.
Add to section 7 Apparatus

- Cooking spray
- Oven: capable of heating sample to a temperature sufficient for sample to be pliable
- Heat resistant gloves.
- Any convenient method for heating splitter and splitter pans in a manner that does not damage apparatus
- A non-contact temperature device such as an infrared temperature gun.

Add to the beginning of Section 8 Procedure:
If the sample does not separate easily, warm the sample in the oven (230° F max) until it can be mixed and separated (not to exceed 2 hrs).
Splitter and splitter pans may be heated, not to exceed 230° F, as determined by a non-contact temperature device; splitter may be sprayed with a light coating of cooking spray, if necessary, to keep fines from sticking to the splitter.

Method B –
Method B may be used for reduction of field samples of SMA or Open-Graded Seal Coat (OGSC) and other bituminous mixtures whose point of acceptance is the plant from truck transports.
Add to section 9 Apparatus:

- Oven: capable of heating sample to a temperature sufficient for sample to be pliable
- Heat resistant gloves
- Do not use canvas blanket for SMA or OGSC

Add to section 10:

If the sample does not separate easily, warm the sample in the oven (230° F max) until it can be mixed and separated (not to exceed 2 hrs). Tools may be heated, not to exceed 230° F.

REDUCING SAMPLES OF HOT MIX ASPHALT TO TESTING SIZE FOP FOR WAQTC TM 5

01
02
03

Mix sample

Significance

Samples of bituminous paving mixes taken in accordance with the FOP for AASHTO T 168 are composites and are typically large in size. Materials sampled in the field need to be reduced to appropriate sizes for testing. As a general rule, field samples should be of a size that splitting once will result in the required test sample size. It is extremely important that the procedure used to reduce the field sample not modify the material properties.

Scope

This method covers the procedure for reducing samples of Hot Mixed Asphalt (HMA) to testing size. The reduced portion is to be representative of the original sample.

04
05

Quartered sample

Apparatus

- Flat-bottom scoop
- Broom or brush
- Non-stick splitting surface such as metal, paper, or heat-resistant plastic
- Large spatulas, trowels, metal straightedges, dry wall taping knives, or sheet metal quartering device
- Thermostatically controlled oven capable of maintaining a temperature of at least 110°C (230°F) or high enough to heat the material to a pliable condition for splitting
- Miscellaneous equipment including trowel(s),

spatula(s), hot plate, non-asbestos heat-resistant gloves or mittens, pans, buckets, and cans

06

Sample Preparation

The sample must be warm enough to separate. If not, warm in an oven until it is sufficiently soft to mix and separate easily. Do not exceed either the temperature or time limits specified in the test(s) method to be performed.

Overview

07

- Large Samples
- Method A: Loaf (Incremental) method
- Method B: Quartering by apex
- Method C: Quartering

Procedure

08

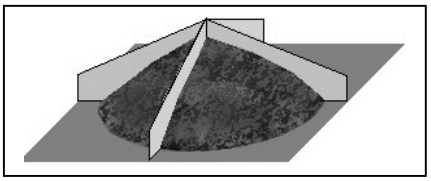
Large Samples, samples over 35 kg (75 lb)

1. Heat the trowel(s), spatula(s), and splitting apparatus to approximately 110°C (230°F).
2. Remove the sample from the agency approved container(s) by dumping into a conical pile on a surface where there will be neither loss of material nor the accidental addition of foreign material. The surface may be covered with heavy paper or other suitable material.

09

3. Mix the material thoroughly by turning the entire sample over a minimum of four times (see Note 1). With the last turning, form the entire sample into a conical pile. Mixing may be accomplished by turning the pile with a heated spatula or by rolling the material over with paper or other material used for the rolling surface. Make a visual observation to determine that the material is homogenous.

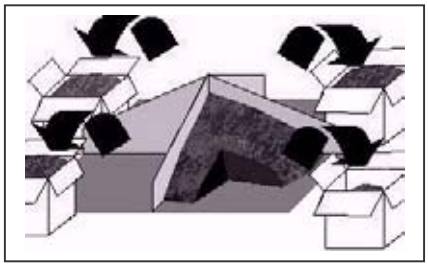
***Note 1*:** Some HMA mixes are prone to segregation; manipulation of the material should be minimized per Agency requirements.



10

Quartering Splitter

4. Flatten the conical pile to a uniform thickness and diameter by pressing down with a hot spatula or trowel. The diameter should be four to eight times the thickness.
5. Divide the flattened pile into four approximately equal quarters with a heated spatula, trowel, flat metal plate, or sheet metal quartering device.
6. Remove each quarter of the material and place in agency approved containers for testing, storage, or shipment. Mark containers per the Sample Identification section.



11

Placing into containers

7. Pay particular attention that excessive amounts of materials are not left on the splitting surface or splitting equipment.

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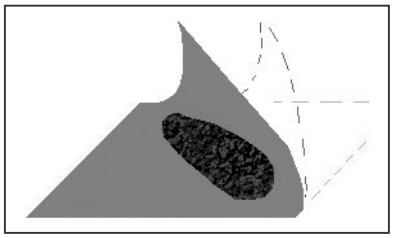
8. When further reduction of the HMA is to be done at this time, reduce by using methods A, B, or C. A combination of the reduction methods may be used if allowed by the agency.



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Mixing HMA

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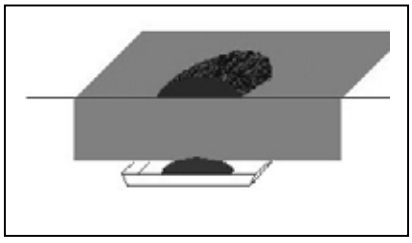
Mixing the sample



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Material dropped into container

Reduction to Test Size

Method A (Loaf / Incremental) method)

1. Remove the sample from the agency approved container(s) by dumping into a conical pile on a surface where there will be neither loss of material nor the accidental addition of foreign material. The surface may be covered with heavy paper or other suitable material.
2. Mix the sample thoroughly by turning the entire sample over a minimum of four times. Alternately lift each corner of the paper and pull it over the sample diagonally toward the opposite corner causing the material to be rolled. With the last turning, lift both opposite corners to form a conical pile. Make a visual observation to determine that the material is homogenous.
3. Grasp the paper, roll the material into a loaf and flatten the top.
4. Pull the paper so at least ¼ of the length of the loaf is off the edge of the counter. Allow this material to drop into a container to be saved. As an alternate, using a straightedge, slice off approximately ¼ of the length of the loaf and place in a container to be saved.
5. Pull additional material (loaf) off the edge of the counter and drop the appropriate size sample into a sample pan or container. As an alternate, using a straightedge, slice off an appropriate size sample from the length of the loaf and place in a sample pan or container.
6. Repeat step 5 until the proper size sample has been acquired. Step 5 is to be repeated until all the samples for testing have been obtained.

Note 2 - When reducing the sample to test size it is advisable to take several small increments determining the mass each time until the proper minimum size is achieved. Unless the sample size is grossly in excess of the minimum or exceeds the maximum test size use the sample as reduced for the test.

Method B (Quartering by apex)

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1. Remove the sample from the agency approved container(s) by dumping into a conical pile on a surface where there will be neither loss of material nor the accidental addition of foreign material. The surface may be covered with heavy paper or other suitable material.
2. Mix the sample thoroughly by turning the entire sample over a minimum of four times. Alternately lift each corner of the paper and pull it over the sample diagonally toward the opposite corner causing the material to be rolled. With the last turning, lift both opposite corners to form a conical pile. Make a visual observation to determine that the material is homogenous.

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3. Flatten the conical pile to a uniform thickness and diameter by pressing down with a hot spatula or trowel. The diameter should be four to eight times the thickness.
4. Quarter the flattened pile using a quartering device or straightedge.
5. With the quartering device in place using a straightedge (taping knife) slice through the quarter of the HMA from the apex of the quarter to the outer edge. Pull or drag the material from the quarter holding one edge of the straightedge (taping knife) in contact with the quartering device. Two straight edges may be used in lieu of the quartering device.

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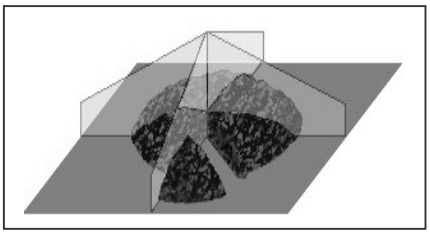
6. Slide or scoop the material into a sample pan.
7. Repeat steps 5 & 6, removing a similar amount of material from the opposite quarter. Steps 5 & 6 are to be repeated until all the samples for testing have been obtained.



HMA from the apex of the quarter to the outer edge.

Note 3- When reducing the sample to test size it is advisable to take several small increments determining the mass each time until the proper minimum size is achieved. Unless the sample size is grossly in excess of the minimum or exceeds the maximum test size use the sample as reduced for the test.

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Method C (Quartering)

1. Remove the sample from the agency approved container(s) by dumping into a conical pile on a surface where there will be neither loss of material nor the accidental addition of foreign material. The surface may be covered with heavy paper or other suitable material.
2. Mix the sample thoroughly by turning the entire sample over a minimum of four times. Alternately lift each corner of the paper and pull it over the sample diagonally toward the opposite corner causing the material to be rolled. With the last turning, lift both opposite corners to form a conical pile. Make a visual observation to determine that the material is homogenous.

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3. Flatten the conical pile to a uniform thickness and diameter by pressing down with a hot spatula or trowel. The diameter should be four to eight times the thickness.
4. Quarter the flattened pile using a quartering device or straightedge.
5. Remove the opposite quarters saving the material for future use.
6. Repeat step 2 through 5 until the proper size sample has been achieved.
7. When additional test specimens are required, dump the removed material into a conical pile as in step 1 and repeat steps 2 through 6. This process may be repeated until sample has been reduced to testing size for all tests.

Sample Identification

1. Identify the sample as required by the agency.
2. Samples shall be submitted in agency approved containers and secured to prevent contamination and spillage.

Tips! 23

- Remember, the reduced sample must be representative of the whole.
- Proceed quickly so that splitting is done when the material is hot.
- Check agency requirements about what splitting device(s) may be used.
- With both methods B & C remember to combine opposite quarters or portions to produce a sample.

REVIEW QUESTIONS

1. Describe how the material is mixed before splitting.

2. What precautions must be taken with the tools used in splitting?

3. What type of equipment can be used to split a sample of bituminous mix?

4. How are methods A, B, & C different?

5. Can methods A, B, and C be used in combination?

PERFORMANCE EXAM CHECKLIST

REDUCING SAMPLES OF HOT MIX ASPHALT TO TESTING SIZE FOP FOR WAQTC TM 5

Participant Name _____ Exam Date _____

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	**Trial 1**	**Trial 2**
1. Sample warmed if not sufficiently soft?	_____	_____
2. Trowels, spatulas, sheet metal quartering device (if used) heated?	_____	_____
3. Sample placed on non-stick splitting surface such as metal, paper, or heat-resistant plastic?	_____	_____
4. Sample mixed by turning over a minimum 4 times?	_____	_____
Method A		
5. Rolled into loaf and then flattened?	_____	_____
6. At least ¼ of loaf removed by slicing off or dropping off edge of counter?	_____	_____
7. Proper sample size sliced off or dropped off edge of counter into sample container?	_____	_____
Method B		
8. Conical pile formed and then flattened?	_____	_____
9. Diameter equal to about 4 to 8 times thickness?	_____	_____
10. Divided into 4 equal portions with heated spatula, trowel, thin metal plate, or sheet metal quartering splitter?	_____	_____
11. With two straight edges or a splitting device and one straight edge. Was one of the quarters split from apex to outer edge of material?	_____	_____
12. Similar amount of material taken from opposite ¼?	_____	_____
13. Cleared spaces scraped clean?	_____	_____
14. Process continued until proper test size is obtained?	_____	_____
Method C		
15. Conical pile formed and then flattened?	_____	_____
16. Diameter equal to about 4 to 8 times thickness?	_____	_____
17. Two diagonally opposite quarters removed?	_____	_____

OVER

18. Cleared spaces scraped clean? _____ _____
19. Process continued until proper test size is obtained? _____ _____
20. Opposite quarters combined to make sample? _____ _____

Comments: First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

_____
_____
_____
_____
_____
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_____
_____

Examiner Signature _____ WAQTC #:_____